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Energy Efficient LEACH protocol for Wireless Sensor Network (EE-LEACH)

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Abstract- Wireless sensor networks are employed in several applications, including military, medical, environmental and household. In all these applications, energy usage is the determining factor in the performance of wire- less sensor networks. Consequently, methods of data routing and transferring to the base station are very important because the sensor nodes run on battery power and the energy available for sensors is limited. There are two reasons behind the hierarchical routing Low Energy Adaptive Clustering Hierarchy (LEACH) protocol be in explored. One, the sensor networks are dense and a lot of redundancy is involved in communication. Second, in order to increase the scalability of the sensor network keeping in mind the security aspects of communication. In this research paper implementation of LEACH routing protocol using NS2 simulator and finally enhanced energy efficient EE-LEACH routing protocol ensures that the elected cluster-heads will be uniformly distributed over the network in order to improve the performance of the LEACH protocol. EE-LEACH improves energy consumption by around 43%.

I. INTRODUCTION

Wireless sensor network (WSN)[1, 2] consists of hundreds and even thousands of small tiny devices called sensor nodes distributed autonomously to monitor physical or environmental conditions, such as temperature, sound, vibration, pressure and motion at different locations. Energy plays an important role in wireless sensor networks because nodes are battery operated [3]. Consequently many protocols have been proposed in order to minimize the energy consumption of these nodes. Each node in a sensor network is typically equipped with one or more sensors, a radio transceiver or other wireless communications device, a small microcontroller, and an energy source, since in most Wireless sensor network applications the energy source is a battery [4], energy plays an important role in wireless sensor network, and preserving the consumed energy of each node is an important goal that must be considered when developing a routing protocol for wireless sensor networks. Many routing protocols have been proposed in the literature such as LEACH [4, 5], PAMAS [6].
Leach is considered as the most popular routing protocol that use cluster based routing in order to minimize the energy consumption; in this paper we propose an improvement on the Leach Protocol that further enhance the Power consumption, simulation results bring out that our protocol outperforms Leach protocol in term of energy consumption and overall throughput.[7]

II. RELATED WORK

Low Energy Adaptive Clustering Hierarchy (LEACH) is the first hierarchical cluster-based routing protocol for wireless sensor network which partitions the nodes into clusters, in each cluster a dedicated node with extra privileges called Cluster Head (CH) is responsible for creating and manipulating a TDMA (Time division multiple access) schedule and sending aggregated data from nodes to the BS where these data is needed using CDMA (Code division multiple access). Remaining nodes are cluster members as shown in figure 1.
This protocol is divided into rounds; each round consists of two phases:

A. Set-up Phase

Each node decides independent of other nodes if it will become a CH or not. This decision takes into account when the node served as a CH for the last time (the node that hasn't been a CH for long time is more likely to elect itself than nodes that have been a CH recently).
In the following advertisement phase, the CHs inform their neighborhood with an advertisement packet that they become CHs. Non-CH nodes pick the advertisement packet with the strongest received signal strength.
In the next cluster setup phase, the member nodes inform the CH that they become a member to that cluster with "join packet" contains their IDs using CSMA. After the cluster-setup sub phase, the CH knows the number of member nodes and their IDs. Based on all messages received within the cluster, the CH creates a TDMA schedule, pick a CSMA code randomly, and broadcast the TDMA table to cluster members. After that steady-state phase begins.

B. Steady-state phase:

Data transmission begins; Nodes send their data during their allocated TDMA slot to the CH. This transmission uses a minimal amount of energy (chosen based on the received strength of the CH advertisement). The radio of

each non-CH node can be turned off until the nodes allocated TDMA slot, thus minimizing energy dissipation in these nodes. When all the data received, CH aggregates these data and sends it to the BS.
LEACH is able to perform local aggregation of data in each cluster to reduce the amount of data that transmitted to the base station.

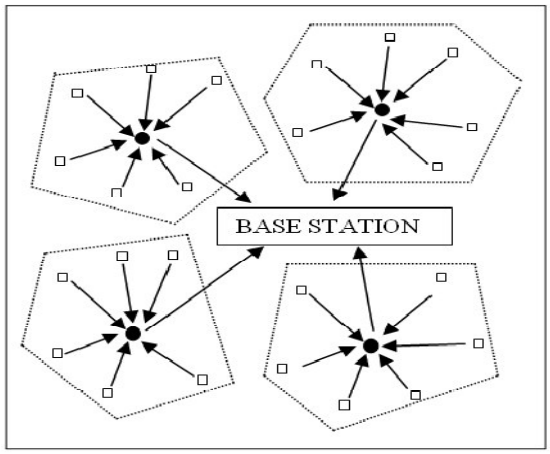

Figure 1: LEACH Protocol Architecture.

Although LEACH protocol acts in a good manner, it suffers from many drawbacks such like;

- LEACH assumes that all nodes begin with the same amount of energy and that the amount of energy a CH consumes is more than that of a non-cluster node.
- LEACH assumes that all nodes can communicate with each other and are able to reach the sink. Therefore, it is only suitable for small size networks.
- LEACH requires that all nodes are continuously listening. This is not realistic in a random distribution of the sensor nodes, for example, where cluster-heads would be located at the edge of the network.
- Finally, there is no mechanism to ensure that the elected cluster-heads will be uniformly distributed over the network. Hence, there is the possibility that most of the cluster-heads are concentrated in one part of the network, which is comparable with the problem like local minima.

Since LEACH has many drawbacks, there is a requirement to make this protocol performs better.
We examined the current state of clustering protocols. Despite the significant overall energy savings approaches, however, the various assumptions made by some protocols raise a number of issues. Like LEACH we assumes that all nodes begin with the same amount of energy, which is however not realistic. It also assumes that all nearby nodes have correlated data which is not always true. PEGASIS assumes that the radio channel is symmetric so that the energy required to transmit a message from node i to node j is the same as energy required to transmit a message from node j to node i for a given signal to noise ratio (SNR). [8] Protocols presented in this offer a promising improvement over conventional clustering; however there is still much work to be done. Many energy improvements so far have focused with minimization of energy associated in the cluster head selection process or with generating a desirable distribution of cluster heads. Optimal clustering in terms of energy efficiency should eliminate all overhead associated not only with the cluster head selection process, but also with node association to their respective cluster heads. [9] Sensor network reliability is currently addressed in various algorithms by utilizing re-clustering that occurs at various time intervals; however the result is often energy inefficient and limits the time available within a network for data transmission and sensing tasks.
The cluster heads could form a multi-hop backbone whereby data are transmitted among cluster heads until they reach the BS. Alternatively, LEACH can evolve into a hierarchical protocol by forming "super-clusters" out of the cluster head nodes and having a "super-cluster head" that processes the data from all the cluster head nodes in the super cluster [10]. These changes will make LEACH suitable for a wider range of wireless sensor networks [11].

III. PROPOSED MODIFICATION IN LEACH

The core operation of a WSN is to gather and convey the collected data to a distant BS for their processing and analysis. Gathering information from a WSN in an energy effective manner is of paramount importance in order to prolong its life span. This calls for use of an appropriate routing protocol to ensure efficient data transmission through the network. As application sensor nodes will periodically switch on their sensors and transmitters, sense the environment, and transmit data of interest at constant periodic time intervals. Thus, they provide a snapshot of the relevant attributes at regular intervals. In the latter type, sensor nodes react

immediately to sudden and drastic changes in the value of a sensed attribute due to the occurrence of a certain event.

The proposed EE-LEACH (Energy Efficient LEACH) routing protocol ensures that the elected cluster-heads will be uniformly distributed over the network. Hence, there is no possibility that all cluster-heads will be concentrated in one part of the network. The performance of the proposed EE-LEACH protocol is evaluated mainly as per the following metrics:

Average Energy consumption: The average energy consumed by the sensor nodes are measured at equal intervals.

Proposed algorithm for EE -LEACH

EE-LEACH employs the distributed clustering approach as compare to LEACH protocol. The total sensor field is divided into the equal sub-region. The choice of the cluster head (CH) from each sub-region is determined by the threshold approach as in LEACH protocol. Following is the algorithm for the EE-LEACH protocol.

PROPOSED EE-LEACH ALGORITHM

1: Let Ni orNj denote a common node
2: S(Ni) = (N1, N2 .....Nn) denote the set of n nodes
3: E(Ni) denote energy in a node
4: Nxyz denote node location
5: Ci denote a cluster ID
6: CH(Ni) denote a cluster head node.
7: dij denote distance measured from node Ni to Nj
8: thresh (Ni) denote the threshold value of node Ni Initialization
9: Create node Ni
10: Set node position Nxyz Clusters formation
11: Divide the sensor field into equal sub-region Ri
12: Select CH from the each sub-region Ri based on threshold value.
13: if Ni Ri&& thresh(Ni) < T hreshold&&hasnotbeenC H yet then
14: Ni = CH (Ni) for sub-region Ri
15: else
16: Ni =Nj (normal node)
17: end if Send Data to Base station
18: CH(Ni) sends data to Base station Repeat the steps 12 to 18 for different rounds
End of algorithm

The sensor field is divided into equal sub region as shown in Figure 2 for 200 nodes.

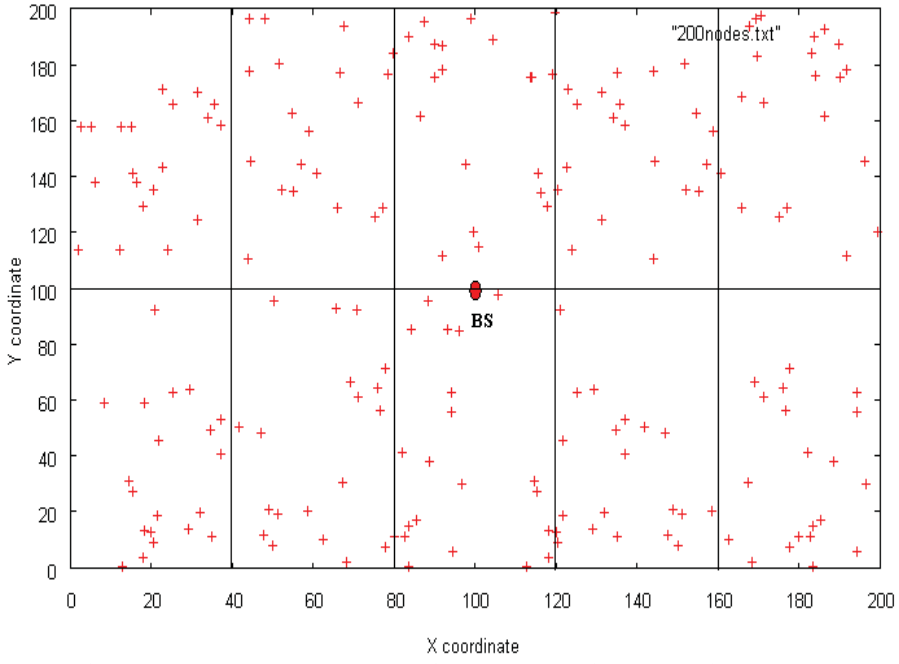

Figure 2: Sensor network topology for 200 nodes with base station at (100,100)

IV. SIMULATION RESULTS AND ANALYSIS

The performance of the proposed EE-LEACH is compared with basic LEACH protocol in terms of Average energy consumption. All experiment results presented in this section are average of three simulation runs in 200 nodes network size. The following table shows the simulation results at various simulation runs.

TABLE 1 VARIOUS PARAMETER VALUES FOR LEACH SIMULATION

Description	Parameter	Value
Radio electronics Energy	E_{elec}	50 nJ/bit
Radio amplifier Energy	$\epsilon_{friss-amp}$ $\epsilon_{two\ ray\ amp}$	$10pJ/bit/m^2$ $0.0013pJ/bit/m^4$
Bitrate	R_b	1Mbps
Antenna Gain factor	G_t, G_r	1
Antenna Height	h_t, h_r	1.5m
Signal Wave length	Λ	$\frac{3*10^2}{914*10^6} = 0.328m$
System loss factor	L	
Cross-over distance	$D_{crossover}$	$\frac{4*\pi*\sqrt{L}*h_r*h_t}{\lambda} = 86\ m$

Average Energy Consumption

As simulation started with equal amount of energy (2J) with each sensor nodes, so total energy with the network will be 200J for 100 nodes and 400J for 200 nodes simulation. Figure 3 and 4 shows the comparison of average energy consumption at various time between LEACH and I-LEACH protocols for 100 and 200 nodes respectively. Here LEACH requires that all nodes are continuously listening while in I-LEACH the total sensor field is divided into the equal sub-region. The choice of the cluster head (CH) from each sub-region is determined by the threshold approach as in LEACH protocol.

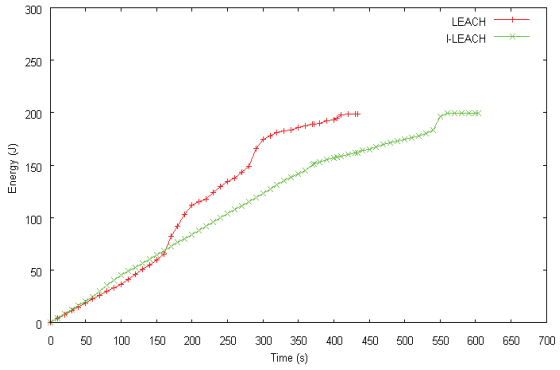

Figure 3: Average energy consumption comparisons (100nodes)

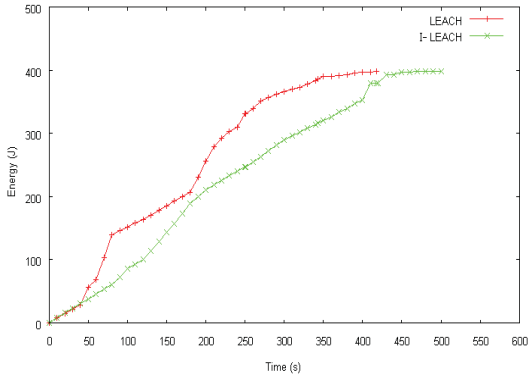

Figure 4: Average energy consumption comparisons (200 nodes)

V. CONCLUSION

In WSNs sensor nodes react immediately to sudden and drastic changes in the value of a sensed attribute due to the occurrence of a certain event. The proposed EE-LEACH ensures that the elected cluster-heads are uniformly distributed over the network. Hence, there is no possibility that all cluster-heads will be concentrated in one part of the network. The result of simulations conducted indicates that the proposed clustering approach is more energy efficient and scalable and hence effective in prolonging the network life time compared to LEACH. It also outperforms LEACH with respect to throughput of the network. EE-LEACH improves energy consumption by around 43% in 100 nodes network size while improves energy consumption by around 44% in 200 nodes network size. And that improvement of LEACH routing protocol helped to improve the performance of WSNs

in Intrusion detection, Weather monitoring, distributed computing, Detecting ambient conditions such as temperature, movement, sound, light, or presence of certain objects.

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