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Leach Enhancement Using Simulated Annealing

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Abstract*—Wireless sensor networks (WSNs) are adhoc networks comprised mainly of small sensor nodes with limited resources (low power, low bandwidth, and low computational and storage capabilities) and one or more base stations (BSs). The sensor nodes collect data from physical environment and after processing send to the base station (BS). Every sensor node has limited energy and in most applications replacing energy sources are not possible. Low-Energy Adaptive Clustering Hierarchy (LEACH) is a clustering based protocol that uses a randomized rotation of cluster heads. In this paper Simulated annealing optimization technique is used to form clusters and cluster head rotation. The enhanced LEACH protocol using SA, called as LEACH_I is simulated on NS2.34. The performance of LEACH and LEACH_I is compared based on three metrics: total energy, total number of alive nodes and total data bits transmitted. Simulation results show that LEACH_I has better performance as compared to LEACH protocol in the given simulation time.

***Keywords*— WSN, BS, LEACH, SA, alive nodes.**

I. INTRODUCTION

Wireless Sensor Network are thus an autonomy system consisting of a number of sensor nodes designed to intercommunicate by wireless radio. These nodes can collaborate monitored, perceived and collected information of various environmental or monitoring objects and transfer this information to the base station in real time. WSN do not require a fixed network support and has rapid employment and survivability [3]. Basically a WSN consist of spatially distributed autonomous sensor nodes to cooperatively monitor physical or environmental circumstances connected in a wireless fashion. Source nodes can transmit their data to target node either directly or through intermediate nodes. These target nodes are connected to the sink or base station (BS). Finally the central gateway provides connection to the wired world where data can be collected analyzed and processed [6].
Figure 1 shows the general architecture of wireless Sensor network.

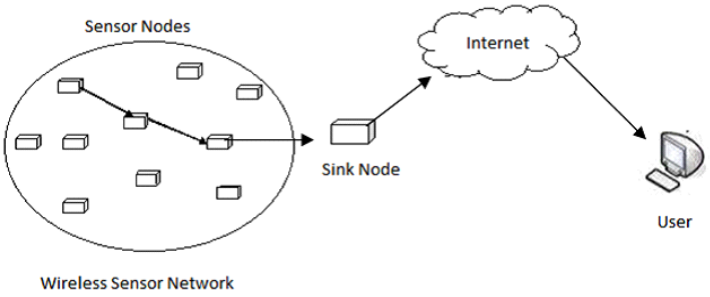

Figure 1. General architecture of wireless Sensor network.

The sensor nodes are used for event detection and continuous sensing which consist of processing unit (for data processing), sensing unit, battery (for energy) and transceiver (for receiving and sending signals or data from one node to another). Sensor nodes can be of varying sizes and its cost depends on parameters like memory size, processing speed and battery. Due to low cost of sensor nodes, a network of hundreds or thousands of nodes is possible which helps to enhance the coverage area as well as reliability of network. These sensors also have data processing and communication capabilities[8]. Routing in WSN is very challenging due to the inherent characteristics that differentiate this network from other wireless networks or cellular networks. The most important constraint on WSN is the limited battery power of sensor nodes and size[6].

LEACH protocol

W.R.Heinzelman introduced a hierarchical clustering algorithm for sensor networks called Low Energy Adaptive Cluster Hierarchy protocol (LEACH). It is one of the most popular hierarchical routing algorithm[2].

LEACH (Low Energy Adaptive Clustering Hierarchy) is a distributed clustering protocol which utilizes randomized rotation of local CHs to evenly distribute energy utilization between the nodes of WSNs. It divides the whole network into several clusters and the run time of network is broken into many rounds. The nodes in a cluster contend to be cluster head according to a predefined criterion. As CHs (Cluster Head) consume more energy in aggregating and routing data it

is important to have an energy-efficient mechanism for CHs' election and rotation. In LEACH protocol, all the sensor nodes have the same probability to be a cluster head which makes the nodes in the network consume energy in a relatively balanced way so as to prolong network.

The whole operation of the LEACH protocol is divided into rounds with each round consisting of:

a) Set-up phase (clusters are organized)

Cluster Head Selection.

Cluster Formation.

b) Steady state Phase (data transmission)

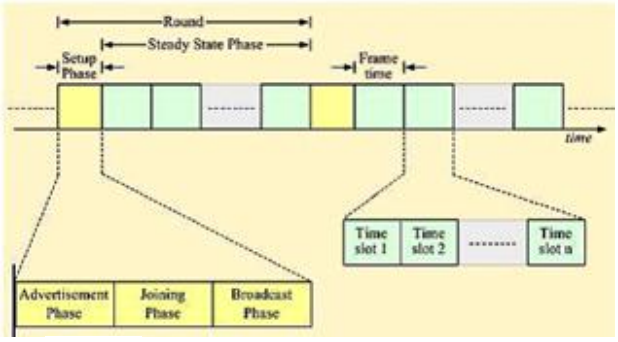

Figure 2: Timeline diagram for LEACH protocol

The main problem with LEACH protocol lies in the random selection of cluster heads. There exists a probability that the cluster heads formed are unbalanced and may remain in one part of the network making some part of the network unreachable[9].

II. RELATED WORK

The author Amiri J. in 2012 [1] proposed LEACH-C method which performs clustering in centralized mode by collecting the energy level of information of every node directly in each period. Also the phenomenon that is seen by sensor nodes continually change over time. Due to this the information received by nodes is correlated. Energy is dissipated as time correlated data is sent in the network. TINA method and its improvement have been proposed in order to not sending correlated data. A model to estimate the remaining energy of nodes by the base station has been presented using time series function. Finally, a method has been proposed to aware the base station from the number of correlated data in each node as the estimation of energy will be more precise. These all ideas have been used over the LEACH-C protocol. Evaluation results showed that the proposed methods had a better performance in energy consumption and the lifetime of the network in comparison with similar methods.

The author Bakaraniya P. in 2013 [2] proposed a modified algorithm for Low Energy Adaptive Clustering Hierarchy (LEACH) called "Kmedoids-LEACH protocol (K-LEACH) for clustered WSN" which is aimed at prolonging the lifetime of the sensor networks by balancing the energy consumption of the nodes. The proposed protocol uses the kmedoids clustering algorithm for uniform clustering and Euclidean distance and maximum residual energy (MRE) is used to select the cluster head (CH).Simulation result shows that K-LEACH improves the network lifespan over LEACH.

The author Chunyao FU in 2013 [3] proposed a new improved algorithm of LEACH protocol LEACH TLCH which is intended to balance the energy consumption of the entire network and extend the life of the network. In LEACH-TLCH (LEACH Protocol with Two Levels Cluster Head) the methods of cluster-head selection and clusters formation are same as LEACH protocol. In it two cluster heads are selected. In a cluster which has secondary cluster head, the secondary cluster head is responsible for receiving and fusing data collected from the member nodes and sending them to its cluster head, the cluster head is only responsible for transporting data to base station. The simulation results indicate that both energy efficiency and the lifetime of the network are better than that of LEACH Protocol.

The author Diwakar M. in 2012 [4] proposed a new algorithm EELBCRP in which the network is partitioned into annular rings by using various power levels at base station and each ring has various sensor nodes. For cluster head selection the residual energy of each node and distance from the BS of nodes is considered. The results are obtained in terms of three metrics- lifetime of the network, number of clusters and energy consumption of clusters heads. EELBCRP reduces the number of dead nodes and the energy consumption to extend the network lifetime. It is observed that the performance of EELBCRP is better in terms of energy consumption of CH, number of clusters and lifetime of network compared with LEACH.

The author Dutta R. in 2014 [5] describes the network quality that depends on different characteristics of data transmission as a modification on LEACH protocol and discusses the comparison of magnitude, phase, group delay, amplitude of broadcasting and energy consumption. Results show that modified LEACH prolong system lifetime.

III. PROPOSED WORK

In the proposed algorithm, the performances of the following metrics are to great concern:

Average number of cluster formation - means the total number of clusters that are formed in network space. Every cluster is headed by a single cluster head. This is defined as the number of the dominated set and it ranges between 1 and N, where N is the number of nodes in the network.

Stability - the number of nodes which will be remaining in the cluster during the simulation time. The stability is decremented when a node is moved out from the current cluster and attached to another cluster.
Load Balancing - Cluster Head can handle the same number of nodes at the same time.
In the proposed algorithm we find clusters for the centralized algorithm.The base station runs a simulated annealing algorithm to determine the set of nodes that minimize the sum of squared distances between the non-cluster-head nodes and the cluster-head nodes. Only nodes with energy above the mean are eligible to become cluster-heads.

IV. RESULTS

In order to compare our proposed protocol LEACH_I with LEACH, we apply three performances metrics for the comparison: numbers of nodes alive, network energy consumed and the data amounts transmitted by the two different protocols. Simulation is done on NS2.34 with following parameters with simulation time 3600 seconds.

Table 1 Simulation Parameters

Parameter	Value
Simulation Time	3600 sec
No. of Nodes	100
BS location	(50, 175)
Numbers of CH	5
Area	100m x 100m
Initial node power	2.5J
Routing Protocol	LEACH
Observation Parameters	Consumed Energy , Data Transmitted, Alive nodes

The figure 3 shows that the proposed protocol transmits the extra bits as compared to LEACH.

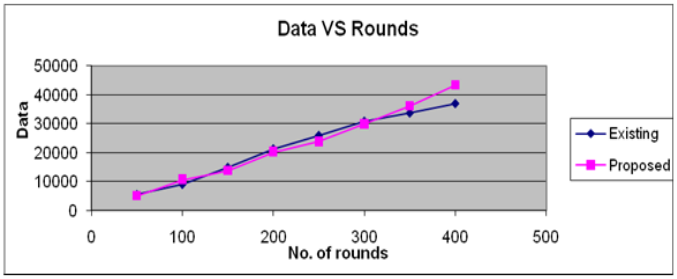

Figure 3 Data Transmitted (bits) vs. No. of rounds

The figure 4 shows that the proposed protocol consumes less energy as compared to LEACH. Hence increases network lifetime compared to LEACH.

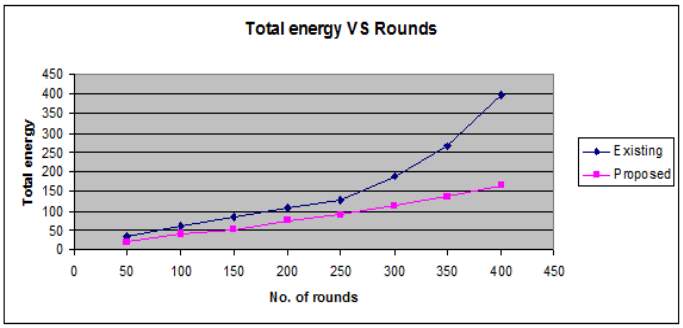

Figure 4 Energy Consumed vs. No. of rounds

Figure 5 shows that numbers of nodes alive in proposed protocol are more as compared to LEACH.

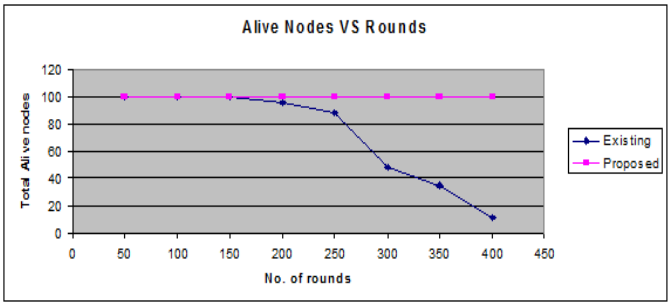

Figure 5 Nodes Alive vs. No. of rounds

Also the proposed protocol works for 708 rounds compared to LEACH which works only for 408 rounds in given simulation time of 3600 seconds.

V. CONCLUSIONS

In this paper, I have presented LEACH protocol with enhancement for providing the proper load balancing scheme to energy efficient LEACH protocol. We have analyzed the behavior and different performance metrics for proposed protocol and LEACH. Graphs of performance comparison shows that proposed protocol has more no of nodes alive after few rounds compared to LEACH. Also the data transmitted is more number of bits as compared to LEACH and the energy consumed in proposed protocol is less as compared to LEACH.

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