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Improved LEACH Protocol for Efficient Transmission of Data in Wireless Sensor Networks using Ant Colony Optimization Algorithm

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Abstract: *Energy Efficiency is one of an indispensible concern in Wireless Sensor Networks (WSNs) which minimizes their efficiency and also shortens the lifetime of network. Many efficient routing as well as algorithmic schemes are proposed in last decade which help in prolonging the lifetime of a network by reduces the consumption of battery by the sensor nodes. Among all the proposed routing schemes, the concept of hierarchical routing plays in important role to overcome the energy efficiency problem of a network. In this paper, an improved version of highly efficient hierarchical routing protocol LEACH is proposed which reduces the consumption of power from the battery by the nodes which help in increasing the lifetime of a network along with Ant Colony Optimization (ACO) algorithm. The simulator used is MATLAB. The Comparative analysis between LEACH and Improved LEACH protocol has been carried out showing that the nodes in Improved LEACH are covering larger rounds which give the efficient outcomes in prolonging the lifetime of the network. The simulation results also reveal that the proposed Improved LEACH protocol outperforms the performance of conventional LEACH protocol in terms of average remaining or residual energy.*

Keywords: *Wireless Sensor Networks (WSNs), Low Energy Adaptive Clustering Hierarchy (LEACH), Improved LEACH, Ant Colony Optimization (ACO), Base Station (BS).*

I. Introduction

Wireless Sensor Networks (WSNs) are composed of small sensor nodes which are deployed in uniform as well as non-uniform or random manner. The nodes are very small in size and vary from few hundreds to thousands of nodes. These nodes are deployed to sense the data and after the sensing the data has to be gathered and compressed. This gathered and compressed data is then sent to the main node which is named as Base Station (BS). The purpose of main node or BS is to make contact with the client node which is only possible through BS. A large amount of energy is consumed by the nodes for the process of sensing, gathering and transmitting purposes. WSNs are capable to reconfigure themselves. These networks can organize themselves after the regular intervals of time [1]. The applications of WSNs vary from seismic detections, military applications and health care applications etc. Instead of various outstanding achievements in several fields, WSNs are still facing very severe challenges in the field of energy efficiency. But, WSNs are highly energy constraint networks which are integrated with a restricted battery or power source which is not feasible to recharge or reinstate. Hence, energy efficiency is one of the major concerns in WSNs for their proper working [2] [3]. Various energy efficient routing techniques like flat, hierarchical and location based routing and algorithms have been proposed which are implemented to face this issue. But, they are still facing many drawbacks. Among these routing techniques, the concept of hierarchical routing plays an important role in which the transference of data takes place by the formation of Cluster Head (CH) within the cluster [4]. The formation of Cluster Heads (CHs) depends upon the random selection of nodes. In the concept of hierarchical routing, all the nodes play the different roles and this technique works on the formation of two layers. The layer which is on the upper side is used to select the CHs and the lower layer is implemented for the process of routing i.e. to route the data from one node to another [4]. Lower Energy Adaptive Clustering Hierarchy (LEACH) protocol is one of an efficient hierarchical routing protocol which is also a cluster based protocol and includes the formation of distributed clusters. In LEACH protocol, the nature of all nodes is homogeneous and they are able to perform the same task which is only the drawback of LEACH [5] [6] [7].

In this paper, an improved version of LEACH protocol is proposed which is known as Improved LEACH. The nature of nodes is heterogeneous in this form of LEACH. This heterogeneity lies in the form of energy assigned to all of the nodes. The nodes with higher energy become the CHs, so that the transference of information from one node to another becomes an efficient process. The algorithm used for the efficient

transmission of data is Ant Colony Optimization (ACO) algorithm which works on the behavior of real ants. Both the protocols are used with ACO algorithm [8] to enhance the lifetime of a network by the reduction in the consumption in energy by the sensor nodes from the battery.

After introducing WSNs and proposed work, the rest of the paper is organized as follows. The section II discusses the concept of LEACH protocol and the proposed Improved LEACH protocol. The section III focuses on the algorithm ACO, applied for the lifetime enhancement of network. The section IV proposes the methodology of proposed work. Simulation Results and Discussion are explained in the section V. The conclusions and future scope is discussed in the last section.

II. Leach And Improved Leach

Low Energy Adaptive Clustering Hierarchy (LEACH) is a hierarchical routing's one of the most efficient routing protocol which works on the formation of CHs within a cluster. The CHs then make contact with each other for the transference of data from one node to another until the data reaches to the final node i.e. BS. LEACH was proposed in the year 2000 by Heinzelman [8] which is also known as Hierarchical Clustering algorithm for sensor networks [9]. The concept of distributed cluster formation in the implementation of LEACH protocol gives the about regarding its cluster-based nature. The working of LEACH protocol is based on the concept of hierarchical routing scheme in which the formation of two layered structure take place. The one layer is used for the selection of the CH while the second layer is used to route the data from one node to another. LEACH protocol works on two phases which are named as setup phase and steady state phase. The work of setup phase is to select the CHs after the proper association of clusters.

On the other hand, the transference of data from one node to another node takes place in the second phase named as steady state phase. To reduce the effect of overhead, the duration of second phase i.e. steady state phase is kept longer than that of setup phase [4]. The working of LEACH protocol in terms of transmitting and receiving of data is based on the allocation of diverse set of Code Division Multiple Access (CDMA) codes which helps in the secure interlink among the nodes. The data received by the CH from the node has to be compressed first before the transmission of data to the BS. This prevents the congestion within the network which helps in increasing the efficiency of the network [10]. The nodes in LEACH protocol are homogeneous in nature which means that all the nodes are equipped with same amount of energy levels and are capable to perform the same tasks of sensing, gathering or compressing and transmitting the data. This is one of the biggest disadvantages in LEACH protocol where the energy level of BS is same as that of other nodes deployed. This also reduces the efficiency of LEACH protocol because the communication at larger distances gets affected by the same energy level of BS as that of other nodes [4][5].

Therefore, to overcome this issue, an improved variant of LEACH protocol is put forward in this paper which is named as Improved LEACH. In this proposed protocol, the concept of homogeneity among the nodes is being introduced. This means that the energy of all the nodes are kept differ from each other. The nodes become able to perform dissimilar tasks such as the variation in the sensing range of the nodes takes place and the power abilities of nodes also changes [11]. In the concept of Improved LEACH in this paper, the impact of heterogeneity lies in the form of energy assigned to nodes. This describes that the nodes with higher energy among other nodes within a cluster become the Cluster Head (CH) so that they can make contact with the nodes situated at larger distances [12].

By introducing the concept of heterogeneity in the LEACH protocol, the nodes can perform diverse set of tasks by which the efficiency of the network can be enhanced in a positive manner. This also reduces the overhead over the nodes because the node with higher energy will become the CH and it will be capable to carry the compressed data over larger distances.

III. Ant Colony Optimization Algorithm

Ant Colony Optimization (ACO) algorithm is one of an efficient algorithm used to enhance the efficiency of a network [8]. The performance of ACO algorithm depends upon the behaviour of real ants. The fundamental arrangement in ACO algorithm is to follow the pheromone trail implemented by real ants as a channel for the process of communication which is used to give feedback to other ants [13]. Primarily, ACO algorithm is a population-dependent, compassionate hunt rule which is presumed to be derived from the activities of real ants. ACO algorithm was mainly enthused by the actions of ants to establish the shortest path to food source from their nest [14]. A huge variety of ants deposit a chemical pheromone trail as they pass from one place to another. The practice goes on till the highest quantity of ants finds the shortest route [15].

In this paper, ACO algorithm is being used with LEACH and Improved LEACH protocols which depends upon the concept of hierarchical routing scheme. The creation of CHs in a well-organized way shows that the effectiveness of LEACH and Improved LEACH becomes more efficient when used with ACO. The flow of information from one node to another always follows the same path as that of ants which follow the same pheromone field which is efficient in nature. The functionality of ACO algorithm is composed of four

phases named as Initialization Phase, Construction Phase, Trail Update Phase and Termination Phase which are explained as follows.

A. Initialization Phase

A set of ants which is also known as colony of ants passes through states of problem equivalent to partial explanations of the difficulty to resolve. The ants shift by the implementation of a stochastic confined judgment strategy based trails and attractiveness which are the two parameters of ACO algorithm [16].

B. Construction Phase

As an ant moves, it constructs a solution to the problem in an addition manner. When an ant completes a resolution during this phase, then the ant analyses the solution. After the analyzation of the solution then the ant amends the value of trail on the mechanism implemented in the solution. This pheromone data or information will direct the investigation of the future ants.

C. Trail Update Phase

The trails by the ants are updated frequently when all of the ants have accomplished a solution, increasing or decreasing the grade of trails consequent to moves that were a portion of Superior or Inferior solutions, respectively.

D. Termination Phase

The last phase in ACO algorithm is termination phase. In termination phase, if the ant does not stores the information or unable to accumulate the information concerning the area covered, then the ant initiates the entire process from the construction phase again [16].

IV. Proposed Methodology

Energy Efficiency is one of the most considerable concerns in WSNs on which the lifetime of a network can be determined. WSNs are integrated with a small or restricted battery source which is very hard of impossible to recharge after the drainage. Hence, many energy efficient techniques are proposed to deal with this vital issue. Many energy efficient routing protocols and algorithms have been put forward to minimize this issue. But, there are some of the drawbacks faced in all the methods applied. LEACH protocol is one of an efficient protocol used to control this issue but because of the deployment of homogeneous nodes, the protocol is not as efficient as required. Hence, in this paper an improved variant of LEACH protocol is proposed which works on the concept of heterogeneity of nodes so that all the nodes can carry out diverse set of tasks. This variant of LEACH protocol is taken as Improved LEACH. The proposed heterogeneity lies in the term of energy allocated to the nodes. The node with higher energy among other nodes in the cluster becomes the CH in the proposed variant of LEACH protocol. By this reason, the CH node can cover or make contact with the far away nodes in order to transfer the data to the larger distances. The overhead also get minimized by the homogeneity in the energy level of the nodes. The comparative analysis of both of the protocols is discussed in the section of results and discussion. The flow of work is discussed in seven stages which are discussed as follows.

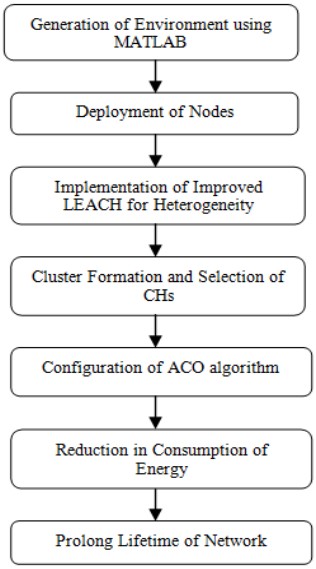

Figure 1. Flow of Work

The figure 1 represents the flowchart of the proposed work. The first phase is the generation of environment using MATLAB. In the second phase, the deployment of nodes is done and the heterogeneity is being provided to the nodes in the phase three after the implementation of Improved LEACH protocol. After the implementation of Improved LEACH protocol the selection of CH within the cluster starts occur on the basis of energy of nodes in fourth phase. The node with higher energy among all the nodes within the cluster becomes the CH for the transference of data to other CH or nodes in nearer as well as larger distances. The fifth phase is the phase where the ACO algorithm gets applied to the protocol proposed for the efficient routing of signal. In sixth and seventh phase, the outcomes are taken showing the enhancement in the lifetime of network by reduction in the consumption of energy from the battery by the nodes.

V. Simulated Results and Discussion

In this section, the simulated results and discussion have been carried out showing the comparative analyzation between conventional LEACH and Improved LEACH protocol. The whole of the work is carried out on a system having core i5 system having 4GB of RAM. The simulator used for the process of simulation is MATLAB 7.11. The simulation results also show the average remaining energy of the nodes used in LEACH and Improved LEACH protocols. The Table 1 is showing the parameters taken for the simulation.

Table II. System Parameters

Parameter	Value
Network Size	100*100
Nodes	100
Initial Energy	1j
Rounds	5000

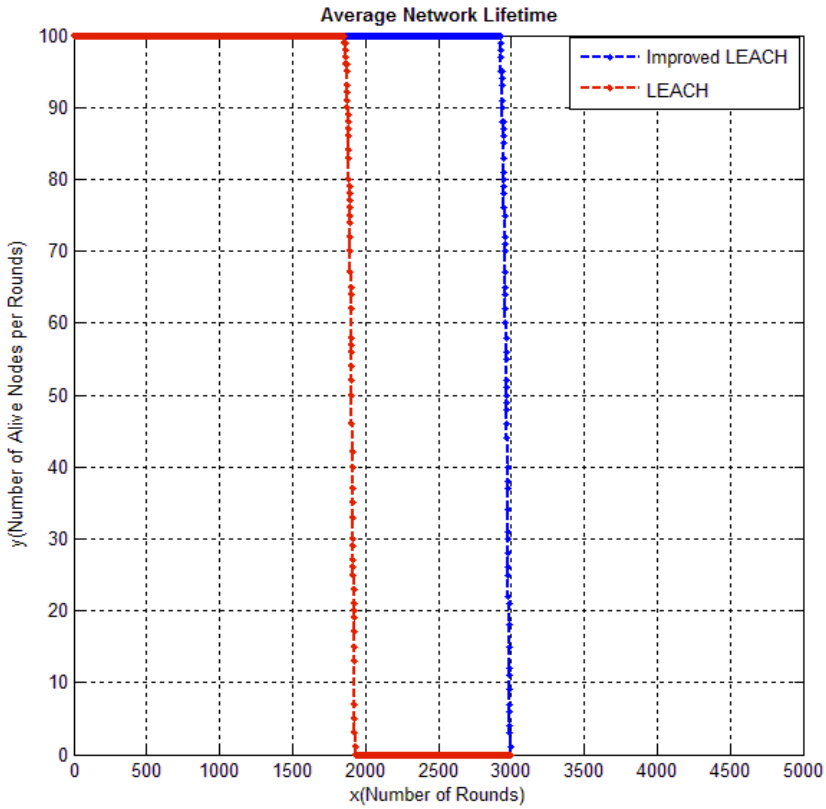

Figure *2.* Average Network Lifetime

Figure 2 shows the comparative analysis of total number of rounds covered by LEACH and Improved LEACH protocols. The representation shows that the proposed Improved LEACH covers the rounds larger than that of traditional LEACH protocol. The Table II shows the rounds covered by conventional LEACH and Improved LEACH protocols where conventional LEACH covers maximum of 1910 rounds and Improved LEACH protocol covers 3000 rounds. This shows that the proposed Improved LEACH protocol is much more energy efficient and prolong the lifetime of network by covering more rounds than that of conventional LEACH protocol.

Table II. Comparative Analysis

Node Mortality	Rounds	
	LEACH	**Improved LEACH**
1%	1850	2900
25%	1870	2930
50%	1880	2950
75%	1900	2970
100%	1910	3000

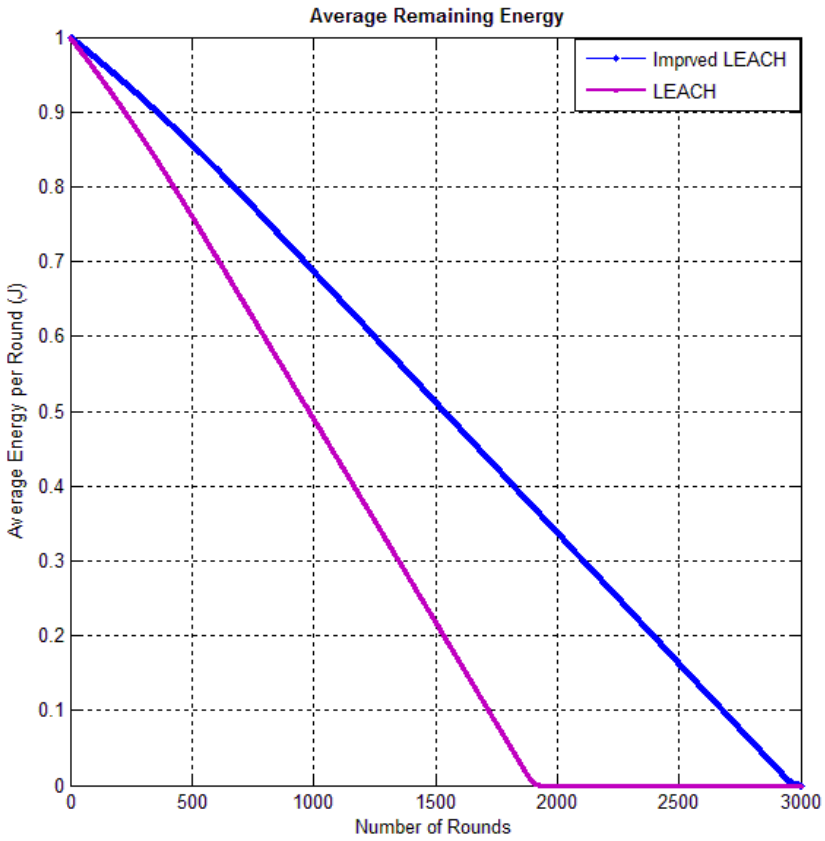

Figure 3. Remaining Energy

Figure 3 represents the average remaining energy of protocols LEACH and Improved LEACH which shows that the Improved LEACH protocol has higher residual energy than that of conventional one.

VI. Conclusion and Future Scope

Energy efficiency in WSNs has to be minimized upto a certain extent in order to achieve a highly efficient network. Because of battery constraint, WSNs are unable to perform in a highly efficient manner and hence to overcome this issue many techniques has been proposed. In this work, the improved variant of LEACH protocol is proposed which deploy the nodes in a heterogeneous behavior. This results in the selection of CH on the basis of energy level and hence CH can communicate at larger distances. Hence, from the simulated results it can easily be concluded that that the implementation of Improved LEACH protocol outperforms the conventional LEACH protocol in enhancing the lifetime of a network by reducing the battery consumption by the sensor nodes.

The future work includes the formation of another variant LEACH which will be high efficient so that the overhead can be minimized upto a certain feasible level.

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