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Efficient Clustering Algorithm Based on Gradient Descent Approach for Wireless Sensor Network

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Abstract: Recent advancement in the field of Wireless Sensor Network leads to design the new protocols for energy conservation. The most important is to develop the clustering based routing protocols which work on the application and network layer. Gradient Descent algorithm has been proposed to find best suited cluster head on the basis of residual energy and distance. This algorithm provides the continuous optimization for a long time. Basically it is an iterative algorithm which is based on the value of cost function which decreases fast in the direction of negative gradient. Results of proposed approach are verified using MATLAB 2015a simulation. This paper targets on improving the network lifetime in terms of number of dead nodes and number of cluster heads and number of packets delivered to base station.
Keywords: Wireless Sensor Network (WSN), Clustering protocols, Cluster head, LEACH.

I INTRODUCTION

Wireless Sensor Network(WSN) consist of huge number of tiny, self directed, low power and circulating devices known as Sensor nodes that have capability to transmit data with each other. These Sensor nodes are deployed in real world environment with one or more than one Base Station (BS) to detect environmental effects. Sensor nodes sense and collect data from environment and transmit data to destination (Base Station). BS is a node that receives data from nodes. Nodes communicate with each other via transceivers. Ad Hoc Network consist of less nodes when compared with Sensor Network [1].

WSN is basically a combination of processing devices, storage devices and wireless communication subsystem for data transmission. All these devices required an effective power supply for smooth communication and data transmission. The power is mostly consumed from the battery which is in a limited amount of time and it takes more time to recharge [2].

To improve energy utilization is to propose routing protocols that define list of rules about how to transmit data packets from source to destination should be known. Routing shows an important role in traffic and environment monitoring. Network operations and Network structure are two main routing techniques which can be further divided on the basis of structure and functions [3].

II RELATED STUDY

Low Energy Adaptive Clustering Hierarchy (LEACH) is one of the most efficient routing methods used by everyone. Different Routing algorithm has been developed for specific application depending upon selection of Cluster Head, rotation of Cluster Head among nodes and transmission of packets to base station. Mu Tong et al. have proposed LEACH-Balance (LEACH-B) protocol to overcome defects in LEACH. Defects can be in form of remaining energy of nodes and variation in number of Cluster Heads. First Cluster Head is selected according to LEACH in each round. Second Cluster Head is modified

depending on node's remaining energy. Number of Cluster head gets constant per round and gets optimal result. LEACH-B prolongs network lifetime and improve energy efficiency [4]. S. Deng et al. have proposed a protocol called mobility based Clusters in which nodes are mobile. In this protocol, nodes can select themselves as Cluster Head on the basis of mobility and remaining energy. In MBC packet loss is reduced by 50% and 25% when compared with LEACH mobile and CBR [5].

TDMA based MAC protocols to reduce energy consumption and to transmit data efficiently has proposed in this work. In this method, nodes go into sleep state if they have no data and if any node has large data to transmit can request for extra time slot. It increases amount of data transmitted during number of cycles and reduces consumption of energy. Results represent that TDMA-B-MAC protocol give better performance than other protocols [6]. Sang H. Kang et al. have proposed a protocol for selection of Cluster Head by considering Distance Threshold. Selection of Cluster Head is performed in distributed manner and algorithm is called LEACH-Distance Threshold. Distributed method requires local information only. Network lifetime is improved by 10% compared with original LEACH [7]. Sudhanshu Tyagi et al. in [8] have compared various Clustering based routing protocols and also discuss about their benefits and drawbacks in comparison with each other. Different metrics considered such as selection of Cluster Head, Lifetime of Network, management of power and energy and transmission of multi hop data. Mohammad Bsoul et al. in [9] have proposed an improvement in LEACH protocol called ECLEACH by considering both distance and energy left in nodes. This improved protocol improves death of first sensor node and remaining energy. In this number of Cluster Head is 0.1 times of number of sensor nodes to keep Network size optimized [9]. Zahra Beiranvand Et al. have proposed an improved LEACH (ILEACH), an efficient routing algorithm which saves inner network communication energy significantly. Election of Cluster Head depends on nodes having more neighbors, high remaining energy and minimum distance from base station. Average energy consumption is reduced up to 62% and WSN performance is improved up to 65% as compared to other routing algorithms [10].

A new value of Threshold is established using Distance based Cluster Head (DBCH) depending on distance and energy left among nodes, Cluster Head and base station. This algorithm uses reduces number of computations and also reduces time complexity [11]. An improved Clustering algorithm depends on distance ratio and weighted energy that helps in saving nodes with more distance and little energy. Residual energy of nodes helps in readjustment of Threshold along with long distance node's factors. Energy utilization rate is increased by 15.9% [12].

C-DTB-CHR-ADD is a protocol where data is distributed adaptively, which provides multi hop and direct communications. Free-space-propagation method is being adopted by Cluster Heads in this approach. Numbers of re-clustering operations are reduced and thus energy optimization is performed [13].Modified Threshold Cluster Head Replacement (MTCHR) to overcome T-LEACH protocol's drawbacks. In this protocol each sensor node has probability to become a CH. It proposes a new method for Threshold energy that results in no data loss and death of first node gets delayed. Consumption of energy is reuced [14].

Honey bee algorithm to find best suited cluster head. During first phase, an objective function is proposed for clustering problem. This scheme helps in forming balanced clusters. Network lifetime is improved [15]. Modified LEACH approach along with modified TDMA scheduling that will minimize energy consumptions and will enhance Network Lifetime. During communication in network energy is balanced among nodes in Clusters. It uses method of election of CH by changing the threshold value deduction formula [16].

III PROPOSED METHODOLOGY

Gradient Descent: Gradient Descent is an optimization algorithm which is used to find the values of parameters of a function which minimize the cost function. This algorithm provides the continuous optimization for a long time. Basically it is an iterative algorithm which is based on the value of cost function which decreases fast in the direction of negative gradient. The Gradient Descent is working effectively by plotting the cost function and put the iteration on the x-axis and y-axis contains the value of cost-function. This method provides the value of the cost function after each iteration of the gradient Descent. This enables you to see the value of your cost function after each iteration of gradient Descent. This lets you easily spot how appropriate your learning rate is. You just try different values for it and plot them all together. When Gradient Descent can't decrease the cost-function anymore and remains more or less on the same level, say it has converged. Note that the number of iterations that Gradient Descent needs to converge can sometimes vary a lot.

Gradient Descent is preferred as it is computational efficient, it produces a stable error gradient and a stable convergence. Simple: No need to compute second-derivative. It is computationally fast per iteration.

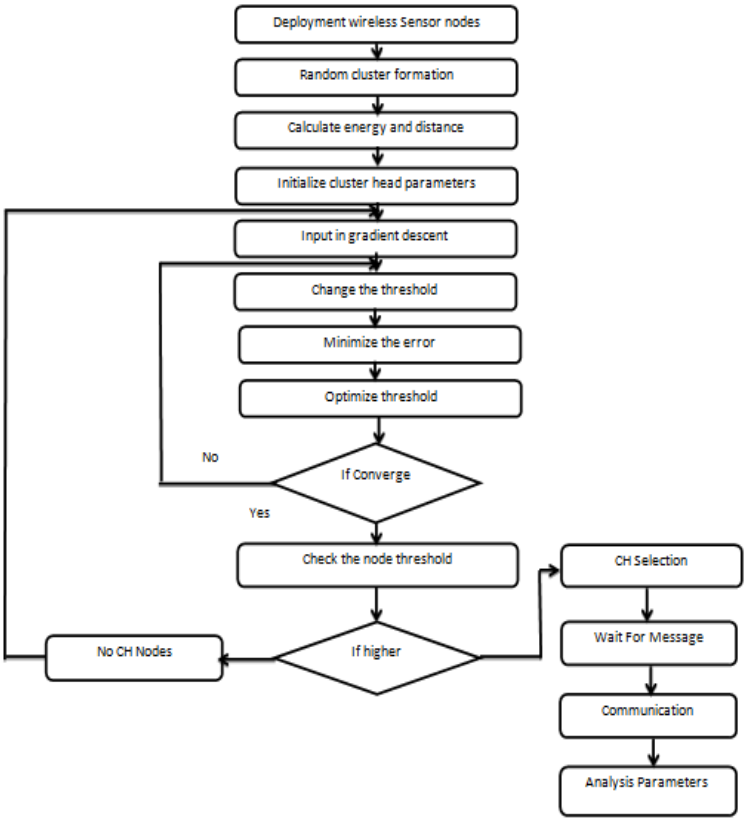

Fig.1 Flow Chart of Gradient Descent Algorithm

Methodology Step

These are methodology steps being followed in order to get improved threshold value for finding best suited cluster head and for making data communication more energy efficient.

Step 1: Wireless sensor nodes are deployed randomly.

Step 2: Clusters are formed randomly after deployment.

Step 3: Calculate the initial energy and distance of the clusters with sensor nodes and base station.
Step 4: After this initialize the parameters for the selection of cluster head.
Step 5: Input the parameters in the Gradient Descent and change the threshold. Gradient Descent changes the threshold and minimizes the threshold.
Step 7: Optimize the threshold and give the best threshold. Best threshold means that value of threshold in which residual energy will be more and distance will be less.
Step 8: Check the threshold converges or not. If it is converge then check the convergence of node otherwise change the threshold. Convergence means when the value of threshold is not increasing or decreasing.
Step 9: If threshold of node is high select the cluster head. Otherwise no cluster head node is found.
Step 10: Communication process will start receiving after message and analyze the parameters.

IV Simulation results and analysis

MATLAB 2015a has been used to analyze proposed algorithm. 100 nodes have been deployed in 100*100 square meter area. The sink node is placed at the network of the network area at (100, 75). All the nodes and sink node are static in nature. The proposed simulation parameters are presented in table 1.

Table 1: Simulation parameter

Parameter	Value
No. of rounds	100
P	0.1 or 100%
$\mathbf{E_{elec}}$	50nJ/bit
$\mathbf{E_{fs}}$	10pJ/bit/$\mathbf{m^2}$
$\mathbf{E_{DA}}$	5nJ/bit/message
$\mathbf{E_{amp}}$	0.0013pJ/bit/4
Control packet size	25 bytes
Data packet size	500 bytes
Number of iteration	400

Results

Number of Cluster heads

Numbers of cluster heads are an impactful factor for WSNs. Fig.2 shows number of cluster heads versus number of rounds. Fig.2 shows number of cluster heads in different rounds. Results show that

improvement in optimal number of cluster head is around 6. More number of cluster heads mean more number of sensor node have enough energy to be selected as cluster head.

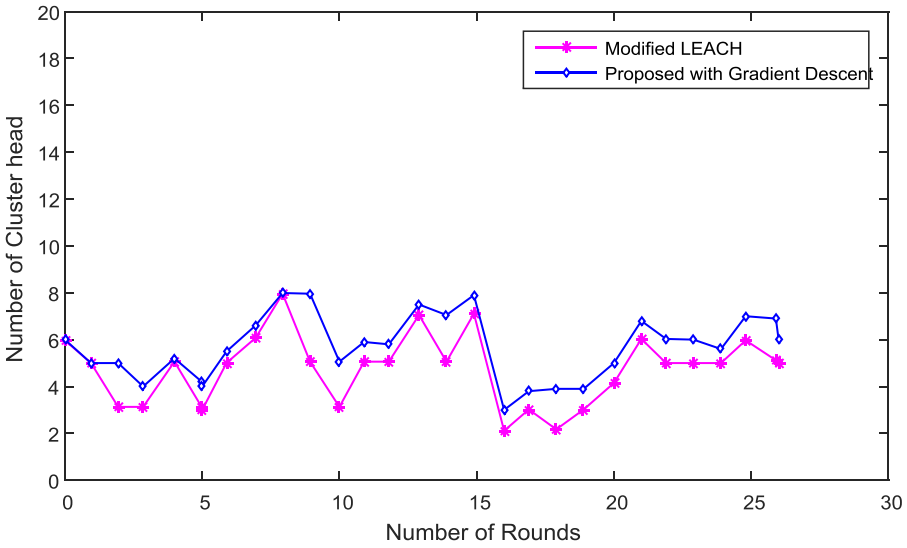

Fig.2 Number of Cluster heads versus Number of rounds

Table 2 shows comparison between existing modified LEACH and proposed Gradient Descent algorithm for different number of rounds.

Table 2: Comparison of Cluster head counts

Rounds	Modified LEACH [16]	Proposed Gradient Descent
5	3	4
12	5	6
26	5	6

Network Lifetime based on Number of Dead nodes

Network lifetime is the amount of time between first node dies and last node dies. Fig.3 shows network lifetime in terms of number of dead nodes versus number of rounds. Existing approach shows FND starts at round 15 and in proposed approach FND starts at round 18. Number of dead nodes is also reduced by using proposed approach.

Table 3 shows comparison between existing modified LEACH and proposed Gradient Descent algorithm.

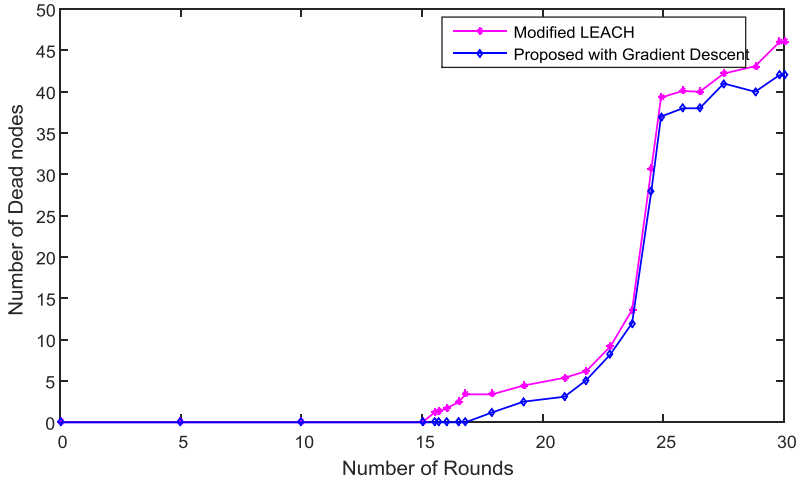

Fig.3 Network lifetime based on number dead nodes

Table 3: Comparison of Dead nodes counts

Rounds	Modified LEACH [16]	Proposed Gradient Descent
14	0	0
24	14	12
30	46	42

Number of Packets at the base station

In the proposed approach number if packets delivered at base station is more than in existing approach. Number of packets is estimated by considering energy consumption. Fig.4 shows the simulation result of proposed Gradient Descent approach. Results show that number of packets delivered by Gradient Descent approach is more than Existing approach.

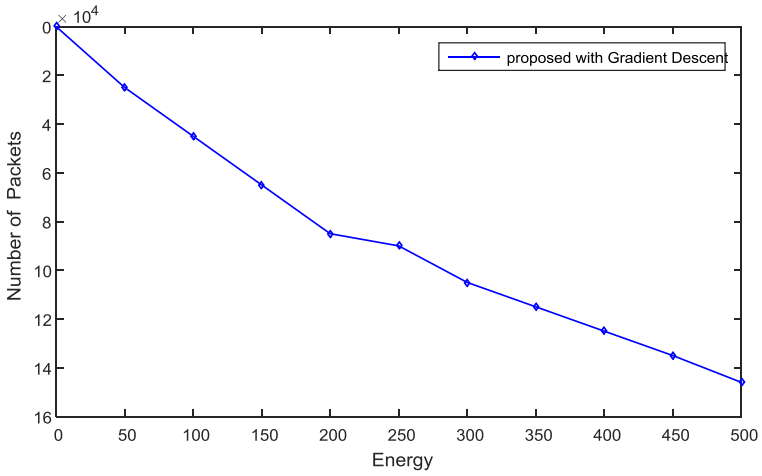

Fig.4 Number of Packets versus Energy (J)

Table 4 shows comparison between existing modified LEACH and proposed Gradient Descent algorithm. More number of packets is delivered at base station.

Table 4: Comparison of Number of Packets delivered

Energy	Modified LEACH [16]	Proposed Gradient Descent
100	25719	45000
300	95785	105000
500	137550	146000

Thus above comparison results shows that proposed algorithm gives better performance and improved results than the existing modified LEACH algorithm in evaluating parameters.

V. Conclusion

In this paper, an efficient approach to enhance network lifetime for WSN is proposed. Gradient Descent algorithm has been used to find best suited cluster head. Result shows that number of cluster head is increased when compared with modified LEACH. It is observed that by using Gradient Descent method first node death starts late as compared with modified LEACH. Results of proposed approach are verified using MATLAB 2015a simulation. This paper target on improving the network lifetime in terms of number of dead nodes, number of cluster heads and number of packets delivered at base station. Results shows that proposed algorithm gives better performance and improved results It does not provide any data security for wireless sensor network and work on security can be done in future.

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