ISSN: 2581-3404 (Online)
International Journal of Innovative Research in Technology and Management, Vol-4, Issue-1, 2020.

Lifetime Enhancement in Wireless Sensor Networks using adaptive clustering and Thresholding

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ABSTRACT
The present work proposes an optimized energy efficient routing protocol for the enhancement of network lifetime n Wireless Sensor Networks. The essence of the protocol lies in the fact that it changes the cluster size as well as the cluster head dynamically at the beginning of every iteration. Moreover, a threshold based approach is used so as to reduce the total number of transmissions thereby bringing down the energy consumption. A delay time is introduced to re-transmit the data in case the transmission thresholds are not exceeded. the average energy of a node and the network lifetime. The network lifetime is evaluated based on the number of rounds transmitted with respect to the number of nodes in the network. It has been found that the proposed algorithm attains almost negligible number of dead nodes over the entire duration of the transmission. The average energy of the nodes decreases with the number of iterations though. Finally it has been shown that the proposed protocol is capable of transmitting more number of rounds with respect to the number of nodes. Thus it can be said that the proposed system achieves better performance compared to previous techniques.

Keywords:- Wireless sensor network, Micro Electro Mechanical Sensors, Routing algorithm, Clustering.

INTRODUCTION

The key encounter is in setting up and legitimate operation of WSN is to expand the lifetime of the system by minimizing the consumption of energy.

Since from last few year mixed bag of progressions have been made to point of confinement the energy necessity in WSN, as principally energy dispersal is more for wireless transmission and reception [1]. Principle methodologies till proposed were centering at rolling out the improvements at MAC layer and network layer to minimize the energy dissipation. Two more real difficulties are the manner by which to place the cluster heads over the network and what number of clusters would be there in a framework. In the event that the cluster heads are accurately situated over the network and sufficient clusters are displayed, it will help to lessen the dispersal of energy and would help to expand the lifetime of the system to handle with all the aforementioned difficulties clustering have been discovered the effective procedure [2] [3]. Clustering is dependably been alluded as a compelling technique to improve the lifetime of WSN.

Technological developments in the field of Micro Electro Mechanical Sensors (MEMS) have enabled the development to tiny, low power, low cost sensors having limited processing, wireless communication and energy resource capabilities. With the passage of time researchers have found new applications of WSN. In many critical applications WSNs are very useful such as military surveillance, environmental, traffic, temperature, pressure, vibration monitoring and disaster areas. To achieve fault tolerance, WSN consists of hundreds or even thousands of sensors randomly deployed inside the area of interest [4].

All the nodes need to send their information towards BS regularly called as sink. Generally nodes in WSN are force compelled because of constrained battery, it is likewise impractical to energize or supplant battery of effectively sent nodes and nodes may be set where they can't be gotten to. Nodes may be available far from BS so control correspondence is not possible because of restricted battery as direct communication obliges high energy. Clustering is the key system for diminishing battery utilization in which parts of the cluster select a Cluster Head (CH). Numerous clustering conventions are outlined in this respect [5, 6]. All the nodes having a place with cluster send their information to CH, where, CH totals information and sends the collected information to BS [7-9]. Under aggregation, fewer messages are sent to BS and only few nodes have to transmit over large distance, so high energy is saved and over all lifetime of the network is prolonged. Energy consumption for aggregation of data is much less as compared to energy used in data transmission. Clustering can be done in two types of networks i.e. homogenous and heterogeneous networks. Nodes having same energy level are called homogenous system and nodes having distinctive energy levels called heterogeneous system. Low-Energy Adaptive Clustering Hierarchy (LEACH) [8], Power Efficient Gathering in Sensor Information Systems (PEGASIS) [10], Hybrid Energy-Efficient Distributed clustering (HEED) [11] are algorithms designed for homogenous WSN under consideration so these protocols do not work efficiently under heterogeneous scenarios because these algorithms are unable to treat nodes differently in terms of their energy. Whereas, Stable Election Protocol (SEP) [12], Distributed Energy-Efficient Clustering (DEEC) [13], Developed DEEC (DDEEC) [14], Enhanced DEEC (EDEEC) [15] and Threshold DEEC (TDEEC) [16] are algorithms designed for heterogeneous WSN. SEP is intended for two level heterogeneous system, so it cannot work efficiently in three or multilevel heterogeneous network. SEP considers only normal and advanced nodes where normal nodes have low energy level and advanced nodes have high energy. DEEC, DDEEC, EDEEC and TDEEC these are intended for multilevel heterogeneous systems and can additionally attain better effectiveness in two level heterogeneous situations. In Heterogeneous Networks nodes have different energy levels. The nodes have more energy has more chance to become CH. To increase the network lifetime DEEC protocol use two types of nodes: advanced node and normal node. To more increase the heterogeneity EDEEC uses 3 types of nodes: Normal, Advanced and super nodes. Super node has more chance to become CH at first transmission rounds. In EDEEC protocol number of super node, advanced nodes and normal nodes and energies are calculated by below formula:

No. of Normal Node = $n*(1-m)$

No. of Advanced Node = $n*m*(1-m_0)$

No. of Super Node = $n*m*m_0$

Energy for Normal Node = E

Energy for Advanced Node = $E_0(1+a)$

Energy for Super Node = E (1+b)

The Value of m, m_0, a, b in EDEEC is predefine.

II CLUSTERING IN HETEROGENEOUS WSN MODEL

With the advancements in the innovation of micro electro mechanical system (MEMS), improvements in wireless communications and wireless sensor networks have likewise developed [4]. Wireless sensor networks (WSNs) have turned into a standout amongst the most intriguing zones of examination in the recent years. A WSN is comprises of countless sensor nodes which structure a sensor region and a sink. These immense amounts of nodes, having the capacities to sense their surroundings, perform constrained count and impart wirelessly structure the WSNs [2]. Particular capacities, for example, alerting, tracking and sensing as depicted [3], might be gotten through participation among these nodes. These parameters make wireless sensors extremely helpful for checking common phenomena, ecological progressions [4], controlling security, assessing activity streams, observing military application [5], and following cordial constrains in the war zones. These undertakings require high trustworthiness of the sensor systems. To make sensor networks more trustworthy, the consideration regarding research on heterogeneous wireless sensor systems has been expanding in later past.

A sensor system might be made adaptable by amassing the sensor nodes into gatherings i.e. clusters. Each cluster has a pioneer, regularly alluded to as the cluster head (CH). A CH may be chosen by the sensors in a cluster or pre-assigned by the system planner. The cluster enrolment may be variable or settled. The thought of cluster routing is likewise used to perform energy proficient directing in WSNs. In a progressive outline, higher energy nodes (cluster heads) might be utilized to process and send the data while low energy nodes could be utilized to perform the sensing. This part talk about the heterogeneous model for wireless sensor network and clustering calculations.

III METHODOLOGY

3.1 Problem Definition

The key challenge encountered in setting up an efficient WSN is to increase the lifetime of the system by minimizing the consumption of energy. Since from last few year mixed bag of progressions have been made to point of confinement the energy necessity in WSN, as principally energy dispersal is more for wireless transmission and reception [1]. Principle methodologies till proposed were centering at rolling out the improvements at MAC layer and network layer to minimize the energy dissipation. Two more real difficulties are the manner by which to place the cluster heads over the network and what number of clusters would be there in a framework. In the event that the cluster heads are accurately situated over the network and sufficient clusters are displayed, it will help to lessen the dispersal of energy and would help to expand the lifetime of the system to handle with all the aforementioned difficulties clustering have been discovered the effective procedure [2] [3]. Clustering is dependably been alluded as a compelling All the nodes need to send their information towards BS regularly called as sink. Generally nodes in WSN are force compelled because of constrained battery, it is likewise impractical to energize or supplant battery of effectively sent nodes and nodes may be set where they can't be gotten to. Nodes may be available far from BS so control correspondence is not possible because of restricted battery as direct communication obliges high energy. Clustering is the key system for diminishing battery utilization in which parts of the cluster select a Cluster Head (CH). Numerous clustering conventions are outlined in this respect [5, 6]. All the nodes having a place with cluster send their information to CH, where, CH totals information and sends the collected information to BS [7-9]. Under aggregation, fewer messages are sent to BS and only few nodes have to transmit over large distance, so high energy is saved and over all lifetime of the network is prolonged. Energy consumption for aggregation of data is much less as compared to energy used in data transmission..

3.1.1 Method of Cluster Head Selection

Let $p_i = 1/n_i$, which might be additionally viewed as the average probability to be a cluster head throughout n_i rounds. At the point when nodes have the same measure of energy at every epoch, picking the average probability pi to be p_{opt} can guarantee that there are p_{opt} N cluster heads each round and all nodes pass on give or take in the meantime. On the off chance that the nodes have diverse measures of energy, pi of the nodes with more energy ought to be bigger than p_{opt}. Let $\bar{E}(r)$ means the average energy at round r of the system, which might be acquired by:

$$\bar{E}(r) = \frac{1}{N}\sum_{i=1}^{N} E_i(r) \qquad (3.1)$$

The probability of the nodes of nodes will be given by:

$$\sum_{i=1}^{N} P_i = \sum_{i=1}^{N} P_{opt}\frac{E_i(r)}{\bar{E}(r)} = \sum_{i=1}^{N}\frac{E_i(r)}{\bar{E}(r)} = Np_{opt} \qquad (3.2)$$

ISSN: 2581-3404 (Online)
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It is the ideal cluster head number. The probability threshold that every node s_i consumes to figure out if itself to turn into a cluster head in each one round, as take after:

$$T(S_i) = \begin{cases} \frac{p_i}{1 - p_i (r mod \frac{1}{p_i})} & if\ s \in G \\ 0 & otherwise \end{cases}$$

(3.3)

Where, G is the set of nodes which are qualified to be cluster head sat round r. On the off chance that node s_i has not been a cluster head throughout the latest n_i rounds, we have $s_i \in G$. In each one round r, when node s_i discovers it is qualified to be a cluster head, it will pick an arbitrary number somewhere around 0 and 1. On the off chance that the number is short of what limit $T(s_i)$, the node s_i turns into a cluster head throughout the present round.

3.1.2 Coping with Heterogeneous nodes

When the networks are heterogeneous, the reference value of each node should be different according to the initial energy. In the two-level heterogeneous networks, we replace the reference value p_{opt} with the weighted probabilities given in below equations for normal and advanced nodes [9].

$$p_{adv} = \frac{P_{opt}}{1 + am}, P_{nrm} = \frac{P_{opt}(1 + a)}{1 + am}$$

(3.4)

Therefore p_i changes to

$$(P_i) = \begin{cases} \frac{p_{opt} E_i(r)}{(1 + am)\bar{E}(r)} & if\ s_i\ is\ the\ normal\ node \\ \frac{p_{opt}(1 + a)E_i(r)}{(1 + am)\bar{E}(r)} & if\ s_i\ is\ the\ advanced\ node \end{cases}$$

(3.5)

Thus the threshold is correlated with the initial energy and residual energy of each node directly.

3.1.3 Average Energy Estimation of Network

In an ideal situation, the energy of the network and nodes are uniformly distributed, and all the nodes die at the same time. Thus estimated average energy $\bar{E}(r)$ of r^{th} round is as follow:

$$\bar{E}(r) = \frac{1}{N} E_{Total}\left(1 - \frac{r}{R}\right)$$

(3.6)

Where, R signifies the aggregate rounds of the network lifetime. It implies that each node expends the same measure of energy in each one round, which is additionally the focus on that energy-efficient algorithms ought to attempt to attain.

The flowchart of the proposed system illustrates the concepts

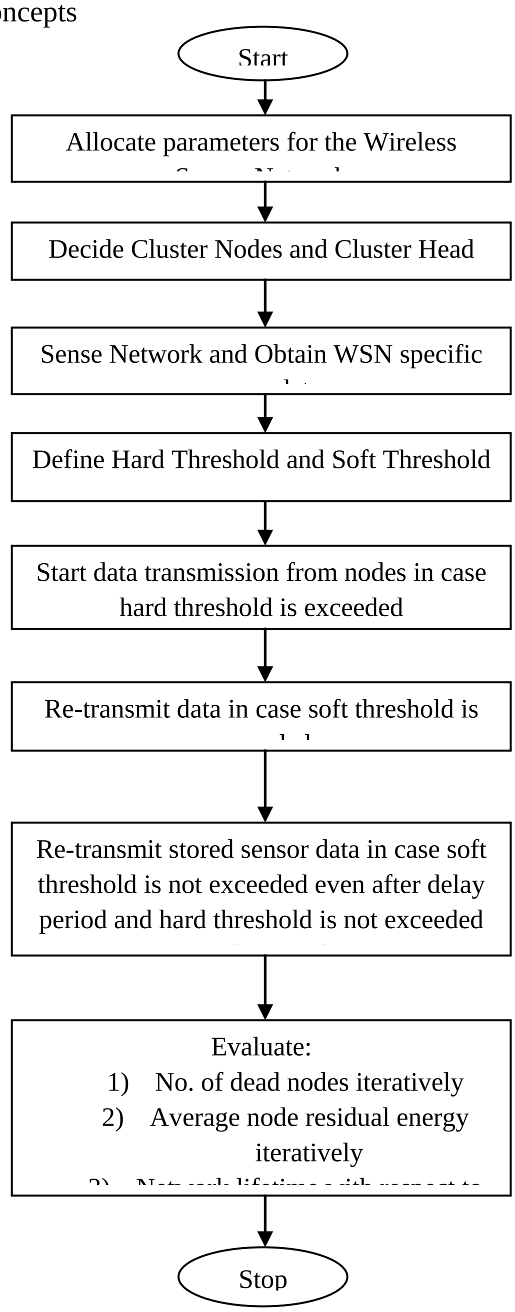

Figure 3.1: Flowchart of Proposed System.

The proposed system is based on minimizing transmissions and transmitting data only when the changes in the data are non-trivial or significant. To implement this kind of an adaptive routing mechanism, a thresholding concept is used. It can be understood using the following diagram.

IV RESULTS AND DISCUSSION

4.1 Simulation Parameters

Table 4.1: Parameters table

Field area	100x100 meter squares
Number of nodes in the field	200
Optimal Election Probability	p=0.2
Initial Energy of nodes	0.1 J
Hard Threshold	200 J
Soft Threshold	2 J
Distance of Base Station	150 m

4.2 Simulation Results

Simulation is carried out using MATLAB 2010a:

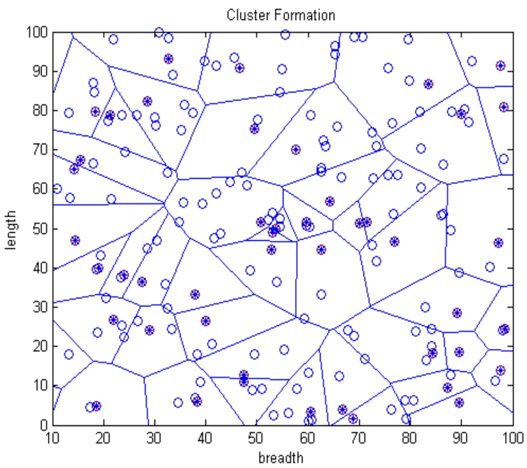

Figure 4.1: Initial Clustering.

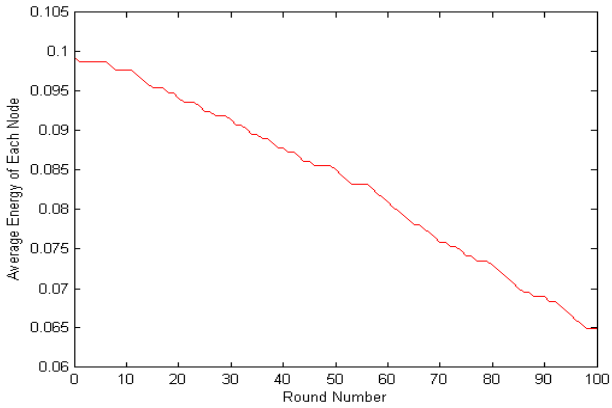

Figure 4.2: Average Energy of Nodes.

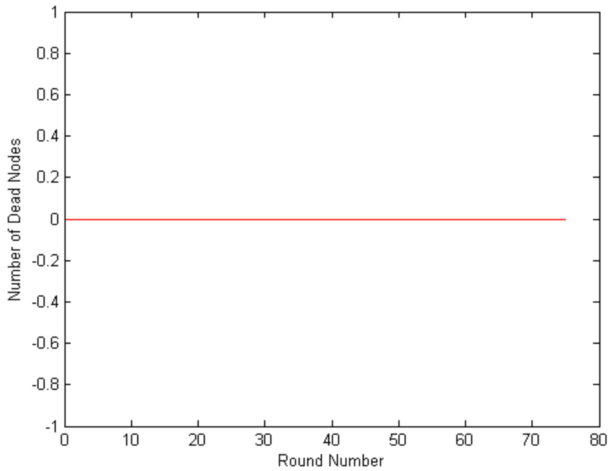

Figure 4.3: Analysis of Dead Nodes.

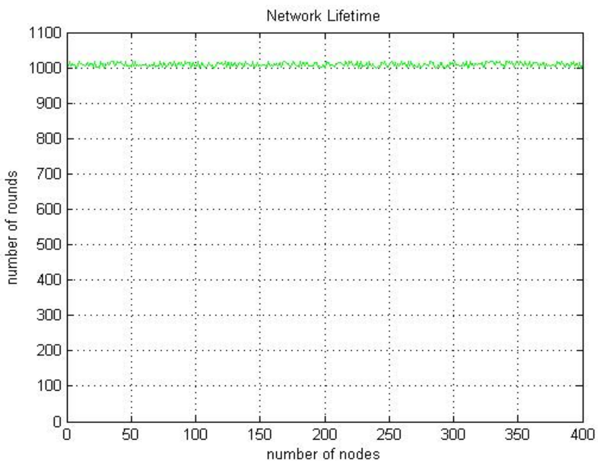

Figure 4.4: Network Lifetime Analysis.

Description of Results Obtained:

Figure.4.1 depicts the initial clustering of the nodes of the sensors based on the residual energy and the limiting distance. It should be noted that the clustering is dynamic and changes with each iteration of information transfer to the control station.

Figure 4.2 depicts the average energy of the nodes as the data transfer from the sensors of the wireless network starts and the iterations increase. It can be clearly seen that the average energy of the nodes dip as the number of iterations increase.

Figure 4.3 shows the number of dead nodes as the number of iterations increase up to 75, where it can be seen that the number of dead nodes is nil.

Figure 4.4 depicts the network lifetime as a function of number of rounds and number of nodes. It can be seen that the proposed system attains around 1000 iterations or rounds as the number of nodes increase up to 400.

V CONCLUSION AND FUTURE SCOPE

In the paper an effective energy efficient adaptive routing algorithm has been proposed. The basic approach used in the algorithm is the dynamic design of the cluster size and cluster head. The cluster heads are decided based on residual energy. The cluster size is decided based on the a particular distance parameter and not on the number of nodes in a particular area of the cluster. This helps each node to communicate to a cluster head that is actually nearest to it. The concept of thresholding i.e. hard thresholding and soft thresholding reduces the number of transmission of the cluster head to the base station thereby reducing the number of transmissions. The results are evaluated based on the number of dead nodes found iteratively, the average energy of the nodes and the number of rounds transmitted with respect to the the number of nodes in the network. It can be concluded from the results obtained that the proposed system reduces the number of transmission based on the soft threshold (step size) and hard threshold approach. The parameters evaluated are number of dead nodes iteratively, average energy per node iteratively and network lifetime as a function of nodes iteratively. It can be seen that the proposed technique attains high value of network lifetime.

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