Efficient Wireless Sensor Networks using Advanced Clustering Schemes

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Abstract - With the advent of the Internet of Things (IoT), clustering algorithms for wireless sensor networks have gained unprecedented importance. A collection of wireless sensor networks constitutes the IoT framework. A Wireless Sensor Network (WSN) is a collection of numbers of connected sensor nodes. Sensor nodes gather the sensory information and communicating with other nodes in networks. A Sensor node typically contains a microcontroller, transceiver, external memory and sensors. The key challenge in wireless sensor network is saving energy and enhances the network life time. To increase the capability of networks, clustering techniques are used. In Clustering techniques, all nodes are divided into several cluster and one of the sensor node is elected as the Cluster Head (CH) and the rest are cluster member (CM). Only the Cluster Head (CH) collects the data from the other node and sends it to the control station or base station. For the process of clustering, cluster head selection and data transfer, several clustering algorithms or complete protocols have been proposed. Although every algorithm has its own pros and cons, still the design for an algorithm that suits to a diasporas of applications and has a comparatively long network lifetime is of paramount importance. 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 : Internet of Things (IoT), Wireless Sensor Networks (WSN),Clustering, Routing,Network Lifetime.

I. 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.

II. PROPOSED METHODOLOGY

In the proposed algorithm, the cluster heads are picked by a chance focused around the proportion between remaining energy of all nodes and the average energy of the system. The ages of being cluster sets out toward nodes are diverse as indicated by their starting and remaining energy. The nodes with high initial and remaining energy will have more potential outcomes to be the cluster heads than the nodes with low energy. In the sensor system considered here, every node transmits sensing information to the base station through a cluster head. The cluster heads, which are chosen occasionally by certain clustering algorithms, total the information of their cluster parts and send it to the base station, from where the end-clients can get to the information. In the heterogeneous system all the nodes of the sensor system are furnished with diverse measure of energy, which is a wellspring of heterogeneity. It could be the consequence of re-energizing the sensor arranges to draw out the lifespan of the system. The new nodes added to the systems will claim more energy than the old ones. Despite the fact that the nodes are outfitted with the same energy at the starting, the systems cannot advance equably for every node in consuming energy, because of the radio communication properties, irregular occasions, for example, transient link failures disappointments or morphological attributes of the field [49]. In the proposed algorithm, there is a provision that every node can use energy consistently by pivoting the cluster head part among all nodes. Thus, the cluster heads are picked by a likelihood established on the degree between the remaining power of every node and the mean power of the system. The round number of the pivoting epoch for every node is diverse as indicated by its initial and remaining energy adjust the rotating epoch of every node to its energy. Nodes with the high initial and remaining energy will have more potential outcomes to be the cluster heads than the lower-energy nodes. Therefore the proposed algorithm can delay the network lifetime, particularly the soundness period, by heterogeneous-aware clustering algorithm.

2.1 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:

$$\bar{E}(r) = \frac{1}{N}\sum_{i=1}^{N} E_i(r) \quad (5.1)$$

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

$$\sum_{i=1}^{N} P_i = \sum_{i=1}^{N} P_{opt}\,\frac{E_i(r)}{\bar{E}(r)} = \sum_{i=1}^{N} \frac{E_i(r)}{\bar{E}(r)} = Np_{opt} \quad (5.2)$$

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:

$$T(S_i) = \begin{cases} \frac{p_i}{1-p_i(r mod \frac{1}{p_i})} & if\ s \in G \\ 0 & otherwise \end{cases} \quad (5.3)$$

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.

2.2 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 [49].

$$p_{adv} = \frac{P_{opt}}{1+am}, P_{nrm} = \frac{P_{opt}\,(1+a)}{1+am} \quad (5.4)$$

Therefore p_i changes to

$$(P_i) = \begin{cases} \frac{p_{opt}\,E_i(r)}{(1+am)\bar{E}(r)} & if\ s_i\ is\ the\ normal\ node \\ \frac{p_{opt}\,(1+a)E_i(r)}{(1+am)\bar{E}(r)} & if\ s_i\ is\ the\ advanced\ node \end{cases} \quad (5.5)$$

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

2.3 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:

$$\bar{E}(r) = \frac{1}{N} E_{Total}\left(1 - \frac{r}{R}\right) \quad (5.6)$$

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.

2.4 Choice of Hard Threshold (HT), Soft Threshold (ST) and Delay Time (T_d)

To enhance the network lifetime further, the proposed approach defines the following parameters:

Hard Threshold: It is the minimum value measeured by the sensor nodes after which the sensor nodes start transmitting the data to the cluster heads. Prior to reaching the hard threshold, the sensor nodes would sense the parameter under consideration but would not transmit the data to the cluster head. It makes sense to use such a technique since the actual value at times may be far off compared to the ideal value of operation.

Soft Threshold: If it so happens that the parameter value reches the ideal range of operation and says there due to the regulation of system cotrolling parameters, then transmitting data at every fixed interval would not yield significant information but would only increae the transmission power needed. The idea is presented by the basics of information theory :

$$I = log_2(1/P_i) \quad (5.7)$$

Here,

I denotes the information contained in an event

P denotes the probability of occurrence of the event.

It can be clearly seen that the saturation of sensor values to a particular level does not yield much information.

Delay Time (T_d) : It may so happen that the transmission form the cluster head to the base station or control station stops if the soft threshold is not exceeded. Futher, a prolonged period of non-transmission results in security and reliability threats. Hence even if the soft threshold is not exceeded, the data is to re-transmitted after the delay time is exceeded.

The flowchart of the proposed system illustrates the concepts.

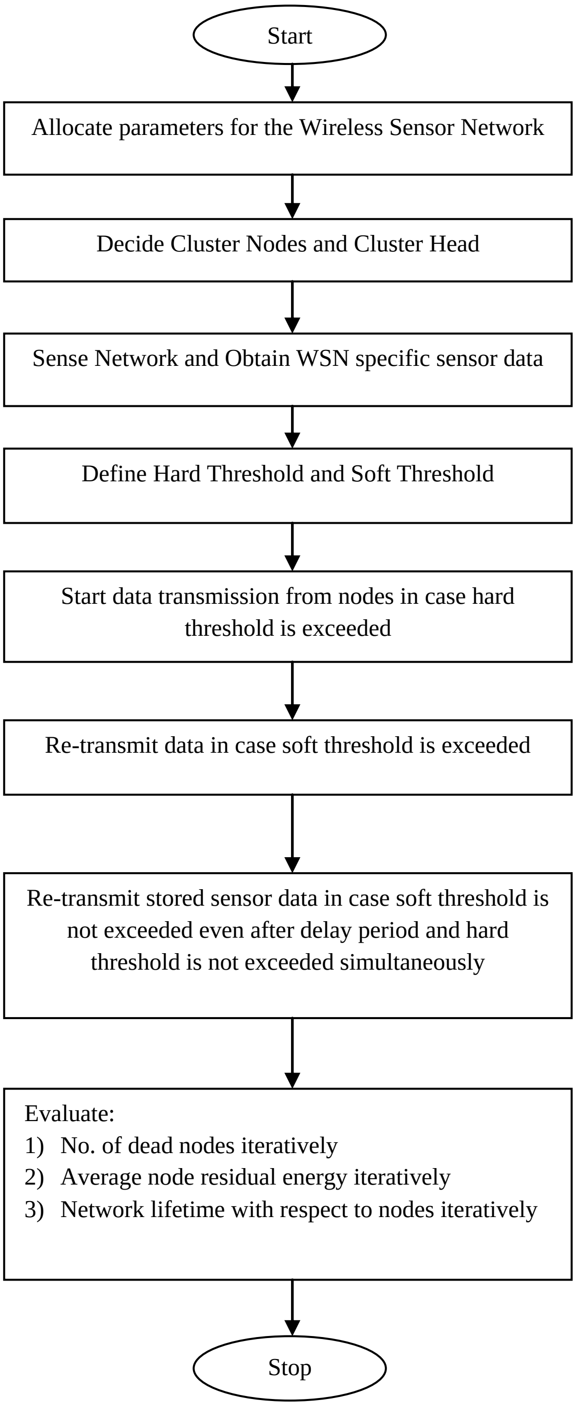

Figure 5.1 Flowchart of Proposed System

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.

The following key points can be noted:

a) Transmission is reduced by assigning a hard threshold and a soft threshold.

b) Assigning a delay time.

c) Transmission is started only after the hard threshold is exceeded

d) Retransmission is done in only 2 cases

   1) Soft threshold is exceeded

   or

   2) Delay time is exceeded

Thus the proposed system reduces the number of transmissions which renders an inference that the network lifetime would increase. The delay time adds a precautionary measure the proposed system.

III. RESULTS

3.1 Simulation Parameters

Table 6.1 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

3.2 Simulation Results

Simulation is carried out using MATLAB 2010a:

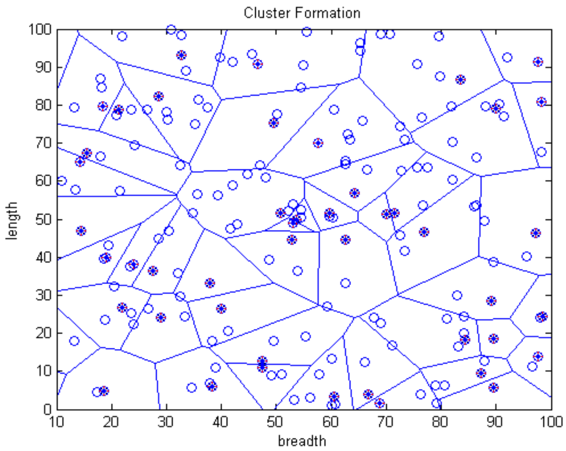

Figure 3.1 Initial Clustering

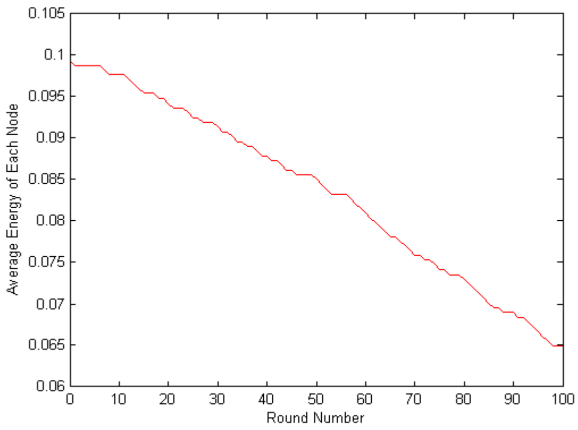

Figure. 3.2 Average Energy of Nodes

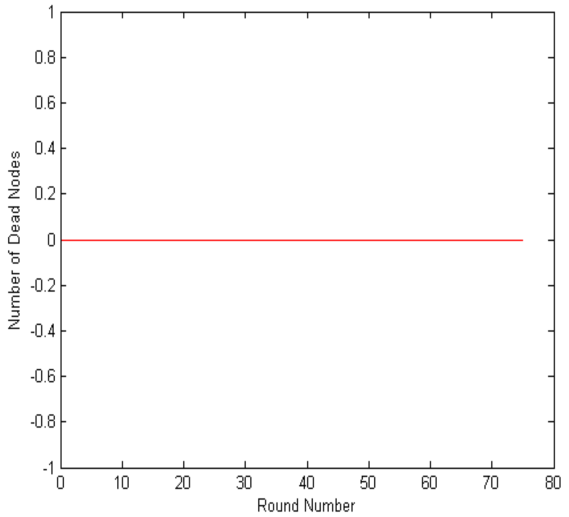

Figure 3.3 Analysis of Dead Nodes

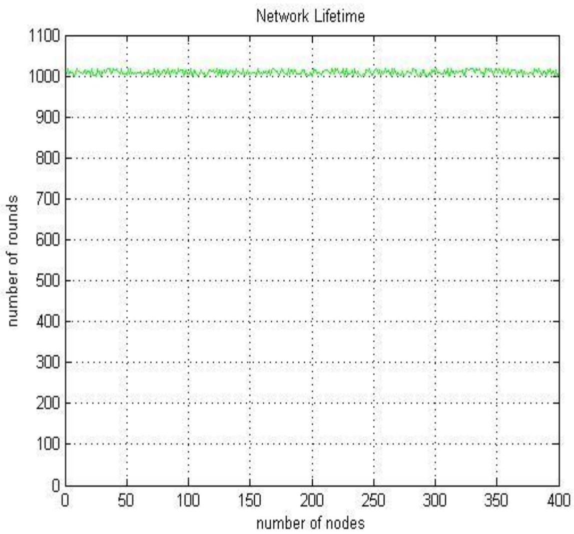

Figure 3.4 Network Lifetime Analysis

3.3 Description of Results Obtained:

Figure.3.1 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 3.2 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 3.3 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 3.4 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.

IV. CONCLUSION AND FUTURE SCOPE

In the present work, 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 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.

There are several avenues where a further research can be targeted, the most prominent of whom are enlisted below.

- Use of genetic algorithm to adapt to network parameters.
- Ausing Artificial Intelligence in predicting network parameters to as to adapt better to the network.
- Using cognitive networks in conjugation to the propsod sytem so as to increase the efficacy of the present system.

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