A NOVEL CLUSTER HEAD SELECTION ALGORITHM FOR WIRELESS SENSOR NETWORK

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Abstract—Wireless Sensor Network (WSN) contains several distributed sensor nodes. Limited Power is the constraint of these nodes. The difficult task is battery recharging. Energy dissipation of nodes influences the lifetime of network. By reducing this, life time can be improved. Improvement of life time of network is by different techniques. One such technique is clustering. The existing methods uses more energy for cluster head selection. This will reduce the network lifetime. Here the author proposes cross layer approach to select cluster head so as to improve network lifetime. In this work overlapping of sensing region of one node with other neighbouring nodes is considered as a parameter for cluster head selection. The node with maximum overlpa with neighbouring nodes will be given chance to become cluster head. Simulation studies are done to obtain performance in terms of the network lifetime. The proposed work is compared with existing $LEACH$ based protocol for networks that contain 500and 750 nodes.

Keywords—cross layer, network connectivity, Network lifetime

I. INTRODUCTION

The sensor nodes in WSN are self configured and have non replacable batteries. As the batteries are non replacable, network failure occurs if a node fails. The nodes are usually seen in unattended environment. Life time of network thus depends on nodes life time. [1] To improve network lifetime energy efficient design is required. Base station and sensing nodes are present in WSN. Data is routed by the sensing node. Sensing node is source node and base station is sink node. After the battery is saturated nodes are no more.

There is a gap between wireless and traditional protocols because of size of network, power supply limitations Energy is saved in multi hop communiction than in direct communication. [2]. The network protocol operation are application specific. The main objective in WSN is maximizing the network lifetime due to battery constaint. Many energy efficient protocol such as $LEACH$ are designed to maximize the network lifetime .The protocol employs hierarchial clustering technique.

A routing protocol $LEACH$ protocol refers to Low Energy Adaptive Clustering Hierarchy [3], is a routing protocol in WSN.This protocol involves random selection of cluster heads. Data is sent by the nodes to the cluster head that is nearer and base station gets the data. After nodes get the beacon message they join the cluster in each round. The strength of the beacon message depends on the cluster size. Energy efficiency can be improved by using clustering techique.
The $LEACH$ algorithm has two phases set up phase and steady state phase. The set up phase involves formation of clusters and selection of cluster head.The steady phase involves the tranmission of data from the cluster nodes to the cluster heads [4].

The paper has the following: The survey is presented in section two. The designed model is presented in next part. The simulations are presented next part

II. LITERATURE SURVEY

There are several approaches proposed to improve the network lifetime. Many clustering protocols are designed to maximize the energy of the network.

$LEACH$ protocol did not consider the remaining energy of the node during cluster head selection.Premature death of node with low energy might occur. Thus life time is reduced .In [4] proposed a technique which considered residual energy of node for cluster head selection.

In [6] $LEACH-TLCH$ (LEACH Protocol with Two Levels Cluster Head) is an improved one based on $LEACH$ protocol, the methods of cluster-head selection and clusters forming are same as $LEACH$ protocol. (LEACH-TLCH) which is intended to balance the energy consumption of the entire network and extend the life of the network .If a cluster head's current energy is less than the average energy, or the distance between the cluster head and base station is longer than the average distance, then the common node with maximum energy in this cluster will be selected as the secondary cluster head.

$(LEACH - C)$ [7] is an extension of $LEACH$. Cluster heads are selected based on details of energy of all nodes. Cluster head selection is done by base station by considering the energy.

$K - LEACH$ is an improved leach protocol . Cluster formation is done by $K - Medoids$ method. Selection of cluster head is by Euclidean distance. The node nearer to the previous cluster head is the cluster head in next round. [8].

In [9], authors have introduced an $AdLEACH$ static clustering based heterogeneous routing protocol with a cluster head selection technique adopted from $DEEC$.It enhances both $LEACH$ and DEEC protocols both in terms of energy efficiency and throughput. In [10], D.Mehmood et.al has given a $MODLEACH$ protocol by introducing efficient cluster head replacement scheme and dual transmitting power levels. Authors in [11] proposed Density Controlled Divide-and-Rule LEACH. This protocol selects optimal number of CHs on the bases of nodes' density such that uniform distribution of load on CHs is maintained throughout the network operation. In [12], authors' proposed Hybrid Energy Efficient Reactive protocol for WSNs. Basically, this protocol aims to maximize network lifetime by minimized transmissions in a heterogeneous environment.
Authors in [13] introduce a routing mechanism which carries the network operation in such a way that the network lifetime is enhaced due to their energy hole removal mechanism. In [14], authors addressed the issues related to throughput maximization and delay minimization, and suggested a linear programming based solution. On the other hand, authors in [15] conducted a comprehensive study on the evaluation of LEACH based clustering protocols, whereas, evaluation of routing protocols on the bases of scalability and traffic constraints is performed in [16]. Moreover, in [17] authors analyzed multi-level Hierarchal routing protocols under the umbrella of energy efficiency through proper route selection.

III. PROPOSED CROSS LAYER MODEL

In this work cluster head is selected based on nodes overlapping..This improves lifetime of network. This is compared with $LEACH$. The basic architecture of the $LEACH$ cluster formation, which will also be used to develop the new algorithm, is shown below. In $LEACH$, some of the nodes are first selected as cluster heads, denoted by CH in Figure 4.1 .Once this has been done, each remaining node joins one of the clusters by determining which of the cluster heads is nearest to itself. In this way, the entire WSN is split into a set of disjoint, non-overlapping clusters centered on the cluster heads, as shown in Figure 4.1

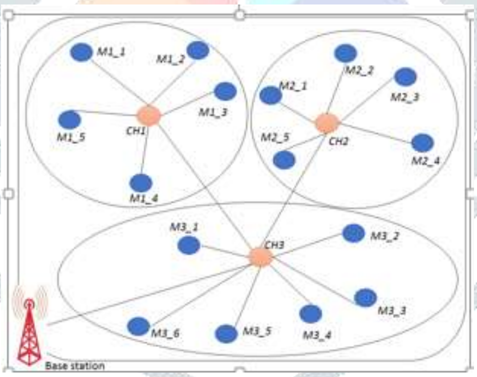

Figure 4.1: The architecture of proposed Cluster formation

In $Leach$ protocol in every round, each node $a$generates a random number from an uniform distribution over the range [0, 1]. This is compared with the threshold H(a) which is computed by the node using (1). If it is less than H(a)then the node a elects itself as cluster-head for that round. Otherwise, it does not serve in the round.A fresh value of the threshold H(a) is computed every time.

$$H(a) = \begin{cases} \frac{s}{1 - s \times [\varphi mod(1/s)]}, & if\ a\epsilon S; \\ 0, & Otherwise. \end{cases} \quad (1)$$

In the above equation, s is the ratio of the desired number of cluster head in each round to the total number of nodes in the network. One typically uses a value ofs equal to 0.05, so the average cluster size is 20 nodes [2]. The quantity the current round number is φ which lies in the range $0 \leq \varphi < \infty$, and S is the set of nodes who are nor selected as heads in previous$1/r$ round. Based on the equation (1), every node determines whether it will serve as a cluster head in a current round. In the next round, the nodes which have already been selected as cluster head in the previous round will not be eligible for cluster head selection.

A. Communication model

Fig 4.2 shows communication model used and it is first order.The quantity $Eamp$ is the energy used by transmitter to operate at the power amplification level for sending a bit to the destination at distance d =1, and the quantity $Eelec$ is the energy needed for both the circuitry in nj (nano joule). This energy is given by equations

$$E_{TX}(L,d) = E_{elec} \times L + E_{amp} \times L \times d^{\alpha} \quad (2)$$

Energy required by receiver is

$$E_{RX}(k) = E_{elec} \times L \quad (3)$$

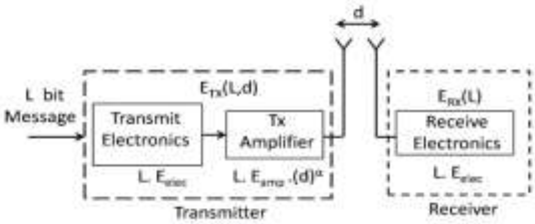

Fig 4.2 first order energy model

Here, the first order free space radio model is used. Hence path loss exponent has a value α=2. In the proposed work, $Eelec$=50 nj/bit and $Eamp$=100pJ/bit/m^2

B. Overlapping model for cluster head selection

The sensing regions of two nodes are shown in Figure 4.3. Sensing region is circle with radius X, where X is assumed value of 3m in this thesis. Y is the distance between the nodes. The arcs of two circles are given by overlap of two sensing regions as shown in Figure 4.4. If distance Y decreases, there is increase in overlap of nodes. Because the amount of energy required for the transmission of a message between a pair of nodes depends on the distance between them, one can use the area of the overlap region as a criterion for the selection of nodes as cluster heads. This concept will be used to improve network life time as compared to that achieved by the *LEACH* protocol.

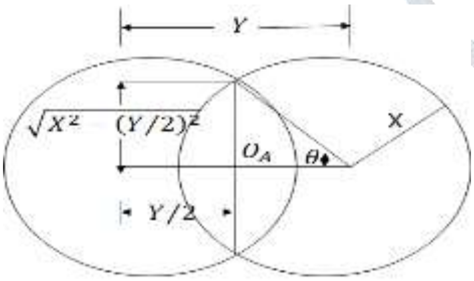

Fig 4.3 overlapping of sensing regions of nodes

The area of overlap of the two sensing regions is as given in (5).

$$O_A = 2X^2 \left[\theta - \frac{Y}{2X} \sqrt{1 - \left(\frac{Y}{2X}\right)^2} \right], \quad (4)$$

Where $\theta = \cos^{-1}(Y/2X)$.

Using this approach, the normalized overlapping Z of a pair of nodes in a network is computed as follows

$$Z = O_A/\pi X^2 = 2\left[\cos^{-1}(r) - r\sqrt{1-r^2}\right]/\pi, \tag{5}$$

Where r ranges from 0 to 1 and $.r = Y/2X$

This quantity$Z$ ranges from 0 to 1. A value of $Z = 1$ indicates the maximum possible overlapping, which occurs whenY= 0 (both sensors are in the same location), while a value of Z= 0 occurs when Y = 2X, and the sensing areas of the two nodes have no overlap. In order to make use of (6), we need a composite value of Y that would represent all nodes in the vicinity of the node in question.

Let R_{sen}denotes the radioreceiver sensitivity. The path loss $M(2X)$ at distance $2X$ can be computed by using the quantity d = 2X. Since we want the signal to be detected at a distance of 2X from the source, but not beyond, the desired power R_{tr} is given by

$$R_{tr} = R_{sen} + M(2X) \tag{6}$$

Let the received radio signal strengthof the message from neighbor n be denoted by R_n, for $n = 1,2,3, \ldots, D$. For each such message n, one has $R_n \geq R_{sen}$, since the distance of transmission is less than 2X. Here $R_n$is expressed in *dbm* (or decibel-milliwatts), which is an abbreviation for the power ratio in decibels (dB). This quantity is related to the corresponding value of R_n in *m*W through the following equation

$$R_n\ in\ dbm = 10\log(R_n\ in\ mW)$$

Hence to obtain (8) below, one first converts each received signal R_n, which is obtained in dbm, into the equivalent R_n, expressed in mW, through the inverse relationship. Next, we find the average of the D such signals, expressed in mW, to get the term in the brackets on the right of (8). Finally, the direct relationship between R_n in dbm and R_n in mW is used to get the equivalent received signal strength R_p, expressed in dbm, as shown in (8) below.

$$R_p = \log_{10}\left[\frac{\sum_{n=1}^{D} 10^{R_n in\ dbm/10}}{D}\right] \tag{7}$$

$$R_{tr} = R_p + M(Y) = R_{sen} + M(2X). \tag{8}$$

$$Y = 2X \times 10^{[R_{sen} - R_p]/10\alpha.} \tag{9}$$

The normalized overlapping region $Z(a)$ for a particular sensor a as follows:

$$Z(a) = O_A/\pi X^2 = 2\left[\cos^{-1}(r) - s\sqrt{1-r^2}\right]/\pi, \tag{10}$$

Where $r = \frac{Y}{2X}$, and the distance Y has been computed by considering the mean signal strength of the D hello signals that were received by the device a.

$$s(a) = s \times Z(a), \tag{11}$$

$$H(a) = \begin{cases} \frac{s(a)}{1 - s(a) \times [\varphi mod(1/(s(a))]}, & if a \in \bar{S}; \\ 0, & Otherwise. \end{cases} \tag{12}$$

IV SIMULATION RESULT

The simulator used is Sensoria. It is dot net based and programming used is C#. Table below has parameters used for simulation.

Fig 4.4, 4.5 show the simulation results of network life time for 500, 750nodes respectively. In Fig. 4.4, 4.5 and 4.6, we can see that the proposed clustering technique performs better than the existing $LEACH$ algorithm in term of network lifetime efficiency. The experimental result shows that the energy efficiency of the proposed algorithm over the existing $LEACH$.The proposed scheme improves the lifetime of sensor network when 500 and 750 nodes are used as shown in fig 4.4 and fig 4.5

Network Parameter	**Value**
Network Size	30m * 30m
Number of sensor nodes	500, 750, 1000
Number of Base stations	1
Initial energy of each sensor node	0.1 J
Radio energy dissipation	50 nj/bit
Data packet processing delay	0.1 ms
Idle energy consumption (Eelec)	50 nj/bit
Amplification energy (Emp)	100 pJ/bit/m2

Table 1 Simulation parameters considered

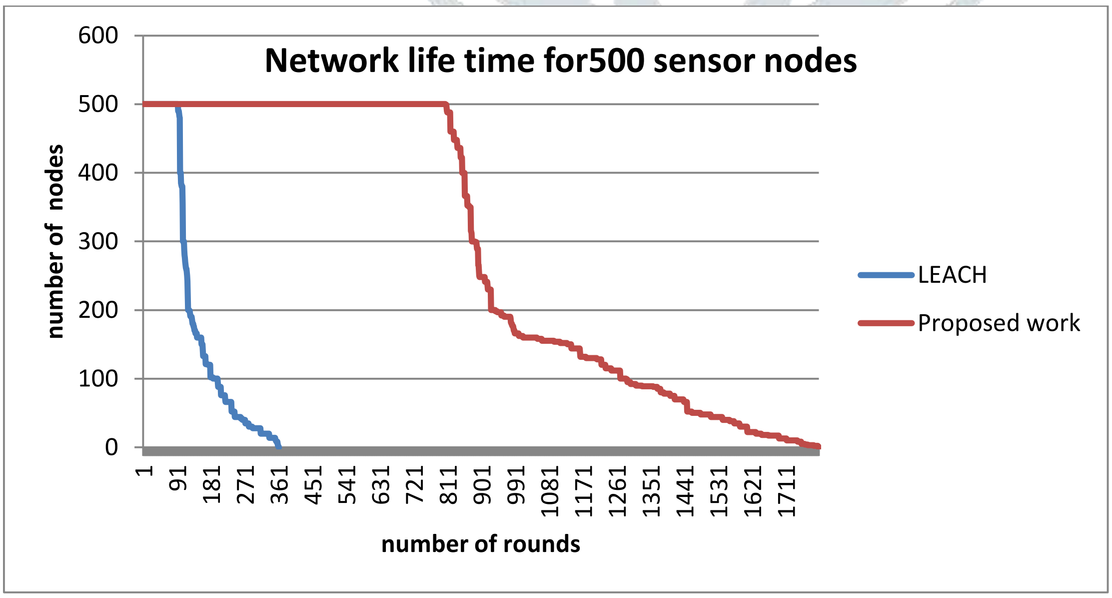

Figure III.4 life time for 500 nodes

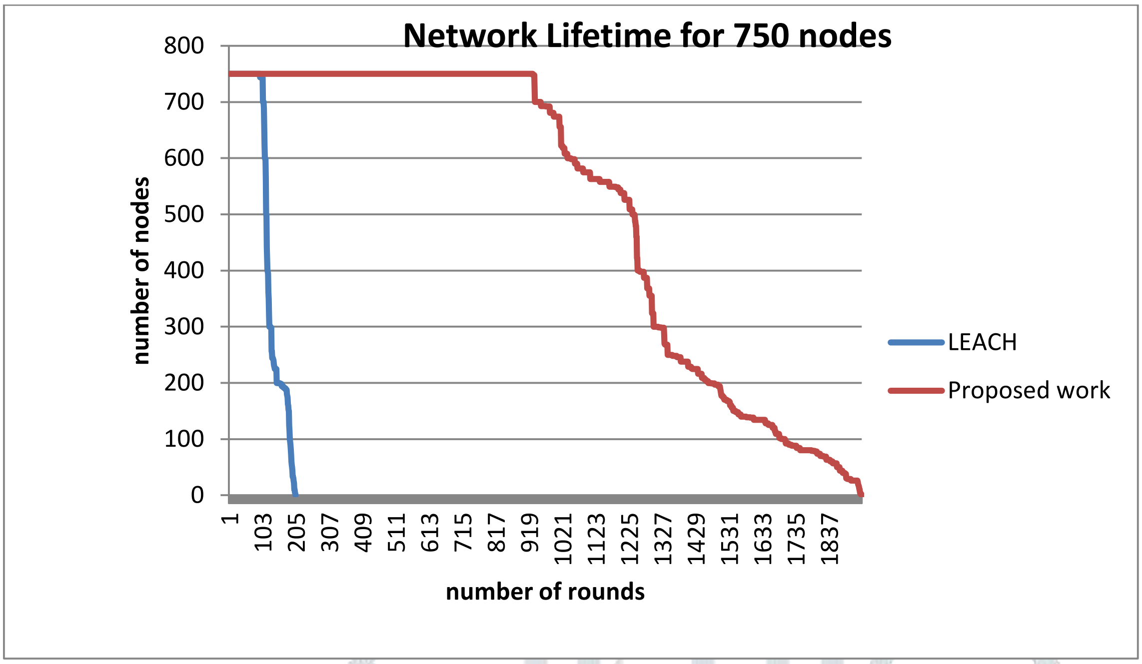

Figure III.5 lifetime for 750 sensor devices

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