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Wireless Sensor Network Lifetime Enhancement Using Multitier Advance (MTA) Leach Protocol

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***Abstract*— Energy is the prime factor for nodes in Wireless Sensor Network (WSN), which can't be reestablish when once installed. To enhance the network lifetime, hierarchical routing is employed. In this paper we aim to improve network lifetime by using Multitier Advance LEACH based protocol by considering residual energy and distance of nodes in WSN. The clustering Algorithm is a type of essential technique used to improve network lifetime. It can raise the scalability of the network. Energy-efficient clustering protocols are constructing for the properties of heterogeneous wireless sensor networks. We propose and evaluate a new Multitier Advance LEACH protocol which is the combination of distributed energy-efficient clustering scheme for heterogeneous wireless sensor networks, (DEEC) and Threshold Sensitive Energy Efficient protocol (TEEN). In DEEC, scheme the cluster-heads are picked by a probability based on the ratio between residual energy of each node and the average energy of the wireless sensor network. The time period of a cluster-heads for nodes is depends on the initial and residual energy. The cluster-head is selected a node having high initial and residual energy than the nodes with low energy. Concussively, the simulation results show that MTA-LEACH achieves elongated lifetime and more impressive memorandum than existing important clustering schemes in heterogeneous environments.**

***Index Terms*— Wireless sensor networks (WSNs) Leach, Genetic algorithm Relay node, E-LEACH, LEACH-X, GADA-LEACH, Multitier Advance LEACH, Network lifetime.**

I. Introduction

A wireless sensor network system is the combination of sensor nodes, sink node and management node. Many number of sensor nodes are installed in the defined area, constructing a network over the means of self-organization. The data controlled through sensor nodes is transfer to other nodes one by one, that will send to the sink node using multi-hop routing and lastly send to the management node through the wired and (or) wireless Internet [2]. The energy, the capability of signal process, storage capacity and communication capability of sensor nodes are very limited. A basic construction aim for wireless sensor networks is to use the energy precisely [3]. Energy utilization is better in Cluster-based routing algorithm as compared with non-cluster routing algorithm [8]. The basic motive of clustering routing[3][7] is to usage the info gathering terminology in the cluster head to curtail the quantity of data transfer, hence, deduct the energy discrimination in communication and in turn achieve the purpose of saving energy of the sensor nodes.

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In the clustering routing for wireless sensor networks, LEACH (low-energy adaptive clustering hierarchy) [4][5] is illustrious because it is easy and adequate. LEACH breaks the complete network into multiple clusters, and the run time of network is broken in to many rounds. In each round, the nodes in a cluster contend to many rounds. In each round, the nodes in a cluster contend to be cluster head according to a predefined criterion. In LEACH protocol, all the sensor nodes have the same probability to be a cluster head, which makes the nodes in the network consume energy in a relatively balanced way so as to prolong network lifetime.

In this paper, we implement the Multitier Advance LEACH (DEEC +TEEN) protocol and study the performance of the many clustering algorithms for network lifetime enhancement for heterogeneous wireless sensor networks. In the sensor network considered here, each node transmits sensing data to the base station through a cluster-head. The cluster-heads, that are selected periodically using some clustering techniques, combined the data of their cluster components and transfer it to the base station, from where the end-users can retrieve the information. We consider that all the nodes of the sensor network are accoutered with different quantity of energy, which is a origin of heterogeneity.

It could be the result of reenergizing the sensor networks in order to enhance the network lifetime [9]. The new nodes added to the networks will own more energy than the old ones. Even though the nodes are equipped with the same energy at the beginning, the networks cannot evolve equably for each node in expending energy, due to the radio communication characteristics, random events such as short-term link failures or morphological characteristics of the field [9]. Hence, WSN are most probably heterogeneous networks.

Among the several routing protocols proposed for WSNs, Multitier Advance LEACH algorithms are more effective in meeting WSNs requirements, mainly Network Lifetime [3-6]. By clustering of sensor nodes into some groups called clusters, SNs of each cluster send their data to specific SNs in the cluster called Cluster Heads (CH). Then, CH nodes transmit gathered information to the BS. Since CH nodes play an important role in the performance of cluster-based routing algorithms, the policy of CH node selection deeply affects network parameters i.e., network lifetime, energy consumption rate.

Figure 1 shows a generalized view of WSNs, which consists of a base station, cluster heads and sensor nodes or a cluster member deployed in a geographical region. Several protocols have applied this concept, i.e., LEACH [7], TEEN [8], and LEACH-EX; however, MTA LEACH, Multitier Advance LEACH protocol is one of the most popular cluster-based routing protocols in WSNs. This algorithm uses a random model to selects CH nodes based on probability.

It should be noted that LEACH algorithm does not consider the residual energy and geographical position of SNs in the

CH selection process. This leads to the early death of sensor nodes and the decrease of WSN lifetime.

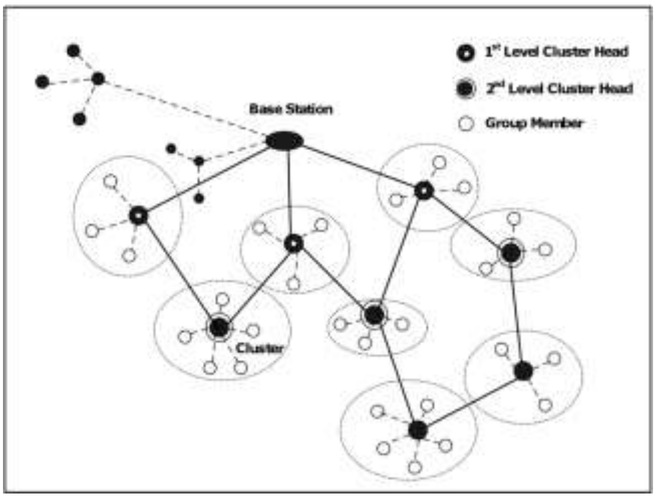

Figure 1: Cluster-based Model

II. LITERATURE REVIEW

The wireless sensor network has been deployed with different wireless networking technologies. The 802.11 protocol is the first standard protocol for wireless local area networks (WLAN), which was introduced in 1997.After that it was upgraded to 802.11b with data rate increased and CSMA/CA mechanism for medium access control (MAC). In 1998 this team developed second generation sensor node by applying some innovations which was named as Wireless Integrated Network Sensors (WINS). These WINS had a processor board with an Intel strong ARM SA1100 32-bit embedded processor (1 MB SRAM and 4 MB flash memory), radio board that supports 100 kbps with adjustable power consumption from 1 to 100 m, a power supply board, and sensor board.

Node first senses its target and then sends the relevant information to its cluster-head. Then the cluster head aggregates and compresses the information received from all the nodes and sends it to the base station. The nodes chosen as the cluster head drain out more energy as compared to the other nodes as it is required to send data to the base station which may be far located. Hence LEACH uses random rotation of the nodes required to be the cluster-heads to evenly distribute energy consumption in the network. After a number of simulations by the author, it was found that only 5 percent of the total number of nodes needs to act as the cluster-heads. TDMA/CDMA MAC is used to reduce inter-cluster and intra-cluster collisions. This protocol is used were a constant monitoring by the sensor nodes are required as data collection is centralized (at the base station) and is performed periodically.

In WSN, Sensor nodes sense the data from impossibly accessible area, cooperatively forward the sensed data to the sink or base station via multi-hop wireless communication and send their report to the base station also called the sink [10]. The nodes in wireless sensor networks can be mobile or stationary and deployed in the area through a proper or random deployment mechanism.

TL-LEACH (Two-Level Hierarchy LEACH) [1] is a proposed extension to the LEACH algorithm. It has two levels of cluster heads (primary and secondary) instead of a single one. Here, the primary cluster head in each cluster communicates with the secondary cluster head, and the corresponding secondary cluster head in turn communicate with the nodes in their sub-cluster. Data fusion can also be performed here as in LEACH. In addition to it, communication within a cluster is still scheduled using TDMA time-slots. The organization of a round will consist of first selecting the primary and secondary cluster heads using the same mechanism as LEACH, with the a priori probability of being elevated to a primary cluster head less than that of a secondary node. Communication of data from source node to sink is achieved in two steps: Secondary nodes collect data from nodes in their respective clusters. Data fusion can be performed at this level. Primary nodes collect data from their respective secondary clusters. Data-fusion can also be implemented at the primary cluster head level. The two- level structure of TL-LEACH reduces the amount of nodes that need to transmit to the base station, effectively reducing the total energy usage. LCTS (Local Clustering and Threshold Sensitive) [12]: It combines the advantages of LEACH and TEEN [11] in terms of short transmission delay and threshold based data gathering. The base station does cluster-head selection. LS-LEACH (Lightweight Secure LEACH) [13] is improved secure and more energy efficient routing protocol Authentication algorithm is integrated to assure data integrity, authenticity and availability. Furthermore, it shows the improvement over LEACH protocol that makes it secure and how to make it more energy efficient to reduce the effect of the overhead energy consumption from the added security measures. It provides security measures to LEACH protocol after indicating the source and limitation of nodes. Also, we develop security measures to protect wireless sensors and the communications from possible attacks without compromising the network performance. For instance, securing LEACH protocol against denial of service attacks while maintaining its performance. Furthermore, the protocol assures that only the authenticated nodes are allowed to join and communicated in the network. At the other hand, we mitigate the overhead cost from the security measures applied to avoid compromising the network performance. Sec-LEACH [14] proposes some creative modifications to LEACH protocol. It shows how to invest the key pre distribution scheme to secure node-to-CH communications. The main idea is to generate a large pool of keys and their IDs at the time the network is deployed, and then each node is assigned a group of these keys randomly. Also each node is assigned with a pair-wise key, which shares with the BS; these keys are used during node-node and node-Base Station communications. This algorithm provides authenticity, confidentiality, and freshness for node-to-node communication. The number of nodes does not impact the security level; actually it depends on the size of the key group assigned for each node according to the total size of the key pool [14].

III. CLUSTERING

In WSNs the sensor nodes are often grouped into individual disjoint sets called a cluster, clustering is used in WSNs, as it provides network scalability, resource sharing and efficient use of constrained resources that gives network topology stability and energy saving attributes. Clustering schemes offer reduced communication overheads, and efficient resource allocations thus decreasing the overall energy consumption and reducing the interferences among sensor nodes. A sensor node can scalable by assembling the sensor nodes into groups i.e. clust ers. Every cluster has a leader, often referred to as the cluster head(CH). A CH may be elected by the sensors in a cluster or pre assigned by the network designer.

IV. LEACH PROTOCOL

Low-Energy Adaptive Clustering Hierarchy (LEACH) [15] [16] is one of the clustering based hierarchical routing protocols. It is used to collect data from wireless network. In the network, hundreds/thousands of wireless sensors are dispersed that collects and transmit data. In these sensor nodes the cluster head's are elected. Because sensor nodes have low energy source and battery cannot be replaced once deployed, the chances of node death scenario is more. So we require LEACH protocol to increase the lifetime of network. LEACH protocol uses random selection cluster head selection and cluster formation. Here the energy is evenly distributed by rotating the cluster head in every round. LEACH protocol is divided into 2 phases:

Threshold is given by

$$T(n) = \frac{P}{1-P\left(r\,mod\frac{1}{p}\right)}\ if\ n\epsilon G \qquad (1)$$

In the above equation (1), the parameters are: p - optimal percentage of CHs in each round. r - current round. G - is set of nodes, which have not been elected as CH in (1/p) rounds. Cluster formation: After cluster head selection, each node broadcasts advertisement (ADV) message using (CSMA/CA) MAC protocol. The near-by nodes send join request to cluster head. It follows a TDMA schedule to setup and transmission and to assign separate time slots to each of its cluster members.

The Steady-state phase consists of transmitting data from cluster members to cluster head during allotted time slots. The cluster head aggregates data and forwards to base station.

So it can easily lead to exhaust the energy quickly in sensor nodes [17].

The LEACH Network is made up of nodes, some of which are called cluster-heads .The job of the cluster-head is to collect data from their surrounding nodes and pass it on to the base station. LEACH is dynamic because the job of cluster-head rotates.

Cluster-heads can be chosen stochastically (randomly based) on this algorithm:

$$T(n) = \frac{P}{1-p\times(rmod\,p^{-1})} \qquad \forall n\epsilon G$$

$$T(n) = 0 \qquad \forall n\epsilon G \qquad (2)$$

Where n is a random number between 0 and 1

P is the cluster-head probability and

G is the set of nodes that weren't cluster-heads the previous rounds

If n < T(n), then that node becomes a cluster-head . The algorithm is designed so that each node becomes a cluster-head at least once.

Cluster Head selection Algorithm Pi(t) is the probability with which node I elects itself to be Cluster Head at the beginning of the round r+1 (which starts at time t) such that expected number of cluster-head nodes for this round is k.

$$E[\#CH] = \sum_{i=1}^{N} P_i(t) * 1 = k. \qquad (3)$$

k = number of clusters during each round. N = number of nodes in the network. Each node will be Cluster Head once in N/k rounds (Round #1,2,3 … Round #N/K, then Round #1, #2, …). – N/K also means cluster size. In each cluster, each sensor has equal chance to become CH. Probability for each node I to be a cluster-head at time

$$P_i(t) = \begin{Bmatrix} \frac{k}{N-k*\left(rmod\frac{N}{k}\right)} & : & C_i(t) = 1 \\ 0 & : & C_i(t) = 0 \end{Bmatrix} \qquad (4)$$

$\sum_{i=1}^{N} C_i(t)$ total no. of nodes eligible to be a cluster head at time t This ensures energy at each node to be 2pprox. Equal after every N/k rounds.

$$E[\#CH] = \sum_{i=1}^{N} P_i(t) * 1 \quad (4)$$

$$= \left(N - k * \left(r\ mod\ \frac{N}{k}\right)\right) * \frac{k}{N-k*(r\ mod\frac{N}{k})} = K \qquad (5)$$

V. E_LEACH

In second proposal, which we call DBEA-LEACH, in order to select the appropriate CH nodes in the CH nodes selection phase, DBEA-LEACH algorithm takes important factors such as position of the sensor node relative to the BS and the amount of residual energy of each sensor node. Similar to DB-LEACH, DBEA-LEACH establishes a new threshold based on distance. In addition, it introduces current energy and initial energy of the node to CH election probability so as to ensure these nodes with higher remaining energy have greater probability to become CHs than that with the low remaining energy. The CH nodes selection directly affects the performance factors of WSN such as load distribution, energy efficiency, and network lifetime.

$$T(n) = \begin{Bmatrix} C \times \frac{|d_{toBSavg} - d(i,BS)|}{d_{toBSavg}} \times \frac{E_i}{E_{init}}, if\ n\epsilon G \\ 0 \end{Bmatrix} \qquad (6)$$

Here, E_i is the residual energy of candidate nodei at the current round. E_{inital} denotes as the initial energy of the node before the transmission. Equation (4) shows that the threshold value depends on the geographical distance between sensor node and the BS and the residual energy of the candidate node.

VI. LEACH-E & LEACH-EX

In our base work we found that better results were obtained by just taking the ratio of current energy and initial energy instead of taking the square root in the formula for threshold calculation T(n) , also use of square root introduces extra computational overhead. The use of square root reduces the overall probability, as the root of number gives a lesser value than just the number itself. As the overall probability is reduced the number of cluster heads getting elected are less.(less than the decided probability P). When the number of number of cluster heads reduces, some nodes have to send data across large distance in order to reach the cluster heads, thus reducing their individual energies and the overall

consumed energy of all the nodes thus increases. Also with different initial energy of the all the nodes LEACH-EX gives better results than LEACH-E. It is called LEACH-EX as an extension to LEACH-E.
The formula used for the threshold in LEACH-EX is

$$T(n) = \begin{cases} \frac{p}{1 - p \times rmod(1/p)} \times \frac{E_{current}}{E_0} & n \in G \\ 0 & otherwise \end{cases}$$

VII. GADA-LEACH

The proposed energy efficient protocol GADA-LEACH is based on GA and distance aware routing. In this, fitness function is computed by using parameters such as energy of all nodes, energy of cluster heads, distance of CH with its associated nodes, number of nodes in cluster, distance of base station from all CH's and number of CH's formed. The entire flow of GADA-LEACH. The steps of the proposed algorithm are described below:

1) The parameters on which the network performance depends are to be initialized in the first step.
2) Then the energy parameters which include initial energy of sensor nodes, energy to run transmitter and receiver, data aggregation and amplification energy are initialized in the second step.
3) The initial population for the cluster head selection is generated. The cluster heads are selected from some number of nodes present in the network.
4) In the next step, after the generation of initial population, the fitness of each node is evaluated for the better results so that the best nodes can be selected as cluster head. Our fitness function includes energy parameters, distance of CH with associated nodes and distance of BS from CH's. Fitness function used is as follows

$$Fitness\ function = [(0.3 * F_1) + (0.35 * F_2)(0.35 * F_3)]$$

$$F_1 = \frac{Energy\ of\ all\ nodes}{Energy\ of\ cluster\ heads}$$

$$F_2 = \frac{Eucledian\ Distance\ of\ CH\ with\ its\ associated\ nodes}{Number\ of\ nodes\ in\ cluster}$$

$$F_2 = \frac{Eucledian\ Distance\ of\ BS\ from\ all\ CH's}{Number\ of\ CH's formed}$$

5) From the fitness evaluated, the best individuals from the population are chosen using Roulette Wheel selection.
6) The crossover and mutation operations are applied for selecting efficient CHs.
7) After applying GA operations, the fitness of the each individual is evaluated again and is compared with the initial one.
8) Since GA minimizes fitness function, if the evaluated fitness is less than the initial population, the current population is updated by the corresponding new generation and next iteration takes place. The population is selected first, then it is updated using genetic algorithm, then again the fitness of the new updated population is evaluated and compared with the initial population's fitness.
9) If stopping criteria meets, then the best nodes are chosen as the cluster heads from that population for that round.
10) After selecting the cluster heads, now communication is initiated between cluster head and nodes. Final communication between cluster head and base station or sink is accomplished by incorporating relay node. This relay node is introduced between sink and the cluster heads. All the cluster heads selected after GA calculate the Euclidean distance from the Base Station (BS) and from the relay node. The aggregated data is sent to the either which has the shortest distance from it.
11. After this the final calculation of parameters is done.

VIII. PROPOSED METHOD HETEROGENEOUS NETWORK MODEL

In this section, we describe the network model. Assume that there are N sensor nodes, which are uniformly dispersed within a M × M square region (Figure: 2)

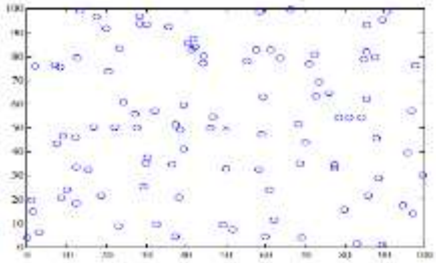

Figure 2: A 100-Node Random Network

Always have data to transmit to a base station, which is often far from the sensing area. This kind of sensor network can be used to track the military object or monitor remote environment. Without loss of generality, we assume that the base station is located at the center of the square region. The network is organized into a clustering hierarchy, and the cluster-heads execute fusion function to reduce correlated data produced by the sensor nodes within the clusters. The cluster-heads transmit the aggregated data to the base station directly. To avoid the frequent change of the topology, we assume that the nodes are micro mobile or stationary.
In the two-level heterogeneous networks, there are two types of sensor nodes, i.e., the advanced nodes and normal nodes. Note E0 the initial energy of the normal nodes, and m the fraction of the advanced nodes, which own a times more energy than the normal ones. Thus there is m N advanced nodes equipped with initial energy of E_0 (1 + a), and (1 - m) N normal nodes equipped with initial energy of E_0.The total initial energy of the two-level heterogeneous networks is given by:

$$E_{total} = N(1-m)E_0 + NmE_0(1+a) = NE_0(1+am) \quad (7)$$

$$E_{total} = \sum_{i=1}^{N} E_0(1+a_i) = E_0\left(N + \sum_{i=1}^{N} a_i\right) \quad (8)$$

As in two-level heterogeneous networks, the clustering algorithm should consider the discrepancy of initial energy in multi-level heterogeneous networks.

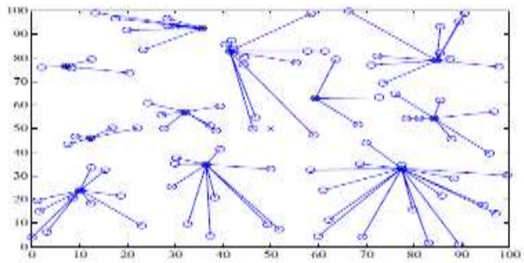

Figure 3: Dynamic Cluster Structure by DEEC algorithm.

MULTITIER ADVANCE LEACH PROTOCOL

Multitier advance leach protocol is the combination of DEEC protocol and TEEN protocol which is used for network lifetime enhancement of wireless sensor network. The details of protocols are given here.

THE DEEC PROTOCOL

In this section, we present the detail of our DEEC protocol. DEEC uses the initial and residual energy level of the nodes to select the cluster-heads. To avoid that each node needs to know the global knowledge of the networks, DEEC estimates the ideal value of network life-time, which is use to compute the reference energy that each node should expend during a round.

CLUSTER-HEAD SELECTION ALGORITHM BASED ON RESIDUAL ENERGY

Let denote the number of rounds to be a cluster-head for the node s_i, and we refer to it as the rotating epoch. In homogenous networks, to guarantee that there are average P_{opt} N cluster-heads every round, LEACH let each node S_i (i = 1,2,. . .,N) becomes a cluster-head once every n_i = 1/Popt rounds. Note that all the nodes cannot own the same residual energy when the network evolves. If the rotating epoch is the same for all the nodes as proposed in LEACH, the energy will be not well distributed and the low-energy nodes will die more quickly than the high-energy nodes. In our DEEC protocol, we choose different n_i based on the residual energy $E_i(r)$ of node s_i at round r.

Let p_i = 1/n_i, which can be also regarded as average probability to be a cluster-head during n_i rounds. When nodes have the same amount of energy at each epoch, choosing the average probability pi to be Popt can ensure that there are Popt N cluster-heads every round and all nodes die approximately at the same time. If nodes have different amounts of energy, p_i of the nodes with more energy should be larger than Popt. Let denote the average energy at round r of the network, which can be obtained by

$$\overline{E} = \frac{1}{N\sum_{i=1}^{N} E_i(r)} \quad (9)$$

To compute E(r) by Eq. (9), each node should have the knowledge of the total energy of all nodes in the network. We will give an estimate of E(r) in the latter subsection of this section. Using E(r) to be the reference energy, we have

$$P_i = p_{opt}\left[1 - \frac{E(r) - E_i(r)}{E(r)}\right] = p_{opt}\frac{E_i(r)}{E(r)} \quad (10)$$

This guarantees that the average total number of cluster-heads per round per epoch is equal to:

$$\sum_{i=1}^{N} p_i = \sum_{i=1}^{N} p_{opt}\frac{E_i(r)}{E(r)} = p_{opt}\sum_{i=1}^{N}\frac{E_i(r)}{E(r)} = Np_{opt}. \quad (11)$$

$$T(S_i) = \begin{cases} \frac{p_i}{1-p_i\left(r \bmod \frac{1}{p_i}\right)} & if\ s_i \in G \\ 0 & otherwise \end{cases}, \quad (12)$$

where G is the set of nodes that are eligible to be cluster-heads at round r. If node s_i has not been a cluster-head during the most recent ni rounds, we have si 2 G. In each round r, when node s_i finds it is eligible to be a cluster-head, it will choose a random number between 0 and 1. If the number is less than threshold T (s_i), the node s_i becomes a cluster-head during the current round.

Note the epoch n_i is the inverse of. From Eq. (10), n_i is chosen based on the residual energy $E_i(r)$ at round r of node s_i as follow

$$n_i = \frac{1}{p_i} = \frac{E(r)}{p_{opt}E_i(r)} = n_{opt}\frac{E(r)}{E_i(r)}, \quad (13)$$

where n_{opt} = 1/popt denote the reference epoch to be a cluster-head. Eq. (13) shows that the rotating epoch n_i of each node fluctuates around the reference epoch. The nodes with high residual energy take more turns to be the cluster-heads than lower ones.

$$p_{adv} = \frac{p_{opt}}{1+am}, \qquad p_{nm} = \frac{p_{opt}(1+a)}{(1+a)} \quad (14)$$

where G is the set n_i of nodes that are eligible to be cluster-heads at round r. If node s_i has not been a cluster-head during the most recent rounds, we have s_i 2G. In each round r, when node s_i finds it is eligible to be a cluster-head, it will choose a random number between 0 and 1. If the number is less than threshold T (s_i), the node s_i becomes a cluster-head during the current round.

Note the epoch n_i is the inverse of p_i. From Eq. (10), n_i is chosen based on the residual energy E_i (r) at round r of node s_i as follow

$$p_i = \begin{cases} \frac{p_{opt}E_{i(r)}}{(1+am)\overline{E}(r)} \\ \frac{p_{opt(r)}E_i}{(1+am)\overline{E}(r)} \end{cases} \quad (15)$$

Where n_{opt} = 1/Popt denote the reference epoch to be a cluster- head. Eq. (13) shows that the rotating epoch n_i of each node fluctuates around the reference epoch. The nodes with high residual energy take more turns to be the cluster-heads than lower ones.

COPING WITH HETEROGENEOUS NODES

From Eq. (10), we can see that P_{opt} is the reference value of the average probability p_i, which determine the rotating epoch n_i and threshold $T(s_i)$ of node si. In homogenous networks, all the nodes are equipped with the same initial energy, thus nodes use the same value to be the reference point of p_i. 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 with the weighted probabilities given in Eq. (14) for normal and advanced nodes [9].

$$p_{adv} = \frac{p_{opt}}{1+am}, \qquad p_{nm} = \frac{p_{opt}(1+a)}{(1+a)} \quad (16)$$

Therefore, p_i is changed into

$$p_{(i)} = \frac{p_{opt}N(1+a)E_i(r)}{(N+\sum_{i=1}^{N} a_i)\overline{E}(r)} \quad (17)$$

Substituting Eq. (15) for p_i on (12), we can get the probability threshold used to elect the cluster-heads. Thus the threshold is correlated with the initial energy and residual energy of each node directly. This model can be easily extended to multi-level heterogeneous networks. We use the weighted probability shown in Eq. (16)

$$p_{(s_i)} = \frac{p_{opt}N(1+a_i)}{(N+\sum_{i=1}^{N} a_i)} \quad (18)$$

to replace Popt of Eq. (4) and obtain the p_i for heterogeneous nodes as

$$p_{(i)} = \frac{p_{opt}N(1+a)E_i(r)}{(N+\sum_{i=1}^{N} a_i)\overline{E}(r)} \quad (19)$$

From Eqs. (16) and (17), $I_i = \left(N + \sum_{i=1}^{N} a_i\right)/p_{opt}N(1+a_i)$ expresses the basic rotating epoch of node si, and we call it reference epoch. It is different for each node with different initial energy. Note $n_i = 1/p_i$, thus the rotating epoch ni of each node fluctuates around its reference epoch Ii based on the residual energy E_i (r). If $E_i > E(r)$, we have $n_i < I_i$, and vice versa. This means that the nodes with more energy will have more chances to be the cluster-heads than the nodes with less energy. Thus the energy of network is well distributed in the evolving process.

ESTIMATING AVERAGE ENERGY OF NETWORKS

From Eqs. (15) and (17), the average energy E(r) is needed to compute the average probability pi. It is difficult to realize such scheme, which presumes that each node knows the average energy of the network. We will estimate E(r) in this paragraph. As shown in Eqs. (10) and (13), the average energy E(r) is just used to be the reference energy for each node. It is the ideal energy that each node should own in current round to keep the network alive to the greatest extent. In such ideal situation, the energy of the network and nodes are uniformly distributed, and all the nodes die at the same time. Thus we can estimate the average energy E(r) of r_{th} round as follows

$$\overline{E}(r) = \frac{1}{N} E_{total}\left(1 - \frac{r}{R}\right), \qquad (20)$$

where R denote the total rounds of the network lifetime. It means that every node consumes the same amount of energy in each round, which is also the target that energy-efficient algorithms should try to achieve. From Eq. (13), considering E(r) as the standard energy, DEEC controls the rotating epoch n_i of each node according to its current energy, thus controls the energy expenditure of each round. As a result, the actual energy of each node will fluctuate around the reference energy E(r) Therefore, DEEC guarantees that all the nodes die at almost the same time. This can be shown by the simulation results of Section 5. In fact, it is the main idea of DEEC to control the energy expenditure of nodes by means of adaptive approach.

To compute E(r) by Eq. (18), the network lifetime R is needed, which is also the value in an ideal state. Assuming that all the nodes die at the same time, R is the total of rounds from the network begins to all the nodes die. Let E_{round} denote the energy consumed by the network in each round. R can be approximated as follow E_{round} denote the energy consumed by the network in each round. R can be approximated as follow

$$R = \frac{E_{total}}{E_{round}} \qquad (21)$$

In the analysis, we use the same energy model as proposed in [13]. In the process of transmitting an l-bit message over a distance d, the energy expended by the radio is given by:

$$E_{Tx}(l,d) = \begin{cases} lE_{elec} + l_{\epsilon f_s d^2}, & d < d_0 \\ lE_{elec} + l_{\epsilon_{mp} d^4}, & d \geq d_0 \end{cases} \qquad (22)$$

where E_{elec} is the energy dissipated per bit to run the transmitter or the receiver circuit, and efsd2 or empd4 is the amplifier energy that depend on the transmitter amplifier model.

We assume that the N nodes are distributed uniformly in an M× M region, and the base station is located in the center of the field for simplicity. Each non-cluster-head send L bits data to the cluster-head a round. Thus the total energy dissipated in the network during a round is equal to:

$$E_{round} = \left(2NE_{elec} + NE_{DA} + k \in_{mp} d_{to\,BS}^4 + N \in_{f_s} d_{to\,CH}^2\right),$$

where k is the number of clusters, EDA is the data aggregation cost expended in the cluster-heads, d to BS is the average distance between the cluster-head and the base station, and d to CH is the average distance between the cluster members and the cluster-head. Assuming that the nodes are uniformly distributed, we can get [13, 10]:

$$d_{toCH} = \frac{M}{\sqrt{2\pi k}}, \qquad d_{toBS} = 0.765\frac{M}{2} \qquad (23)$$

By setting the derivative of E_{round} with respect to k to zero, we have the optimal number of clusters as

$$k_{opt} = \frac{\sqrt{N}}{\sqrt{2\pi}}\sqrt{\frac{\epsilon_{f_s}}{\epsilon_{mp}}}\frac{M}{d_{toBS}^2} \qquad (24)$$

Substituting Eqs. (22) and (23) into Eq. (21), we obtain the energy E_{round} dissipated during a round. Thus we can compute the lifetime R by (19). Because of the affection of the energy heterogeneity, the nodes can't die exactly at the same time. If let R of the estimate value to avoid such situation. This also means that the premise of the energy of the network and nodes being uniformly distributed is not prerequisite in practical operation of DEEC. The approximation of R is enough to get the reference energy E(r) thus DEEC can adapt well to heterogeneous environments. Initially, all the nodes need to know the total energy and lifetime of the network, which can be determined a priori. In our DEEC protocol, the base station could broadcast the total energy E_{total} and estimate value R of lifetime to all nodes. When a new epoch begins, each node s_i will use this information to compute its average probability pi by Eqs. (18) and (19). Node s_i will substitute pi into Eq. (15), and get the election threshold T (s_i), which is used to decide if node s_i should be a cluster-head in the current round.

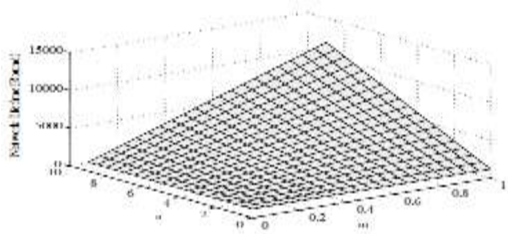

Figure 4: Estimation of Network Lifetime

First, consider a random observation order strategy in which the PU pair constructs the observation sequence randomly at every time slot. Since the observation variable set $\{X_1, X_2, \ldots, X_M\}$ is independent for each time slot, the efficiency of this order strategy is uncontrollable. Due to the poor performance of the random observation order strategy, take into consideration an intuitive order.

IX. RESULTS

The algorithm was implemented in MATLAB simulation tool. The toolbox of MATLAB 7.10.0 is used for simulation of graphical comparison.

This is the result section, here we shows the comparison among the performance of nodes in wireless sensor network based on two parameters (i) with different energy level (0.3J/node, 0.4J/node, 0.5J/node) (ii) with different packet sizes (2000 bit/packet ,3000 bit/packet, 4000 bit/packet) five Routing protocols, LEACH, E-LEACH, LEACH-EX, GADA

LEACH ,MTA LEACH .

The performance is shown by multiple graphs as describe below (from figure no: 6 to 22)

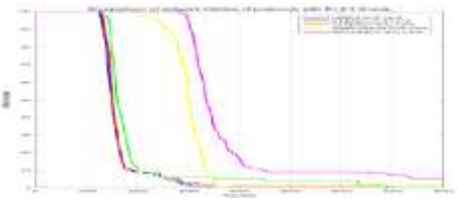

Figure 5: Network Lifetime Comparison of different protocols (at Initial energy $E_0 = 0.3J/Node$)

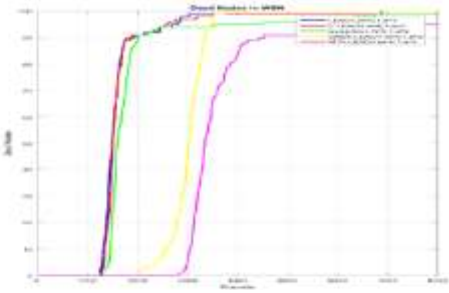

Figure 6: Dead Nodes in the WSN

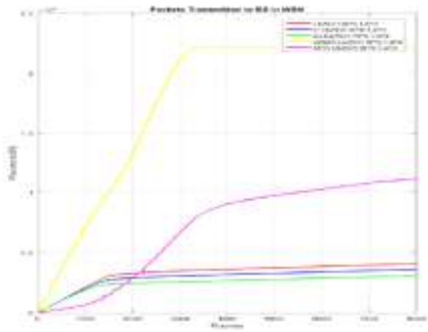

Figure 7: Packet Transmitted to BS in WSN

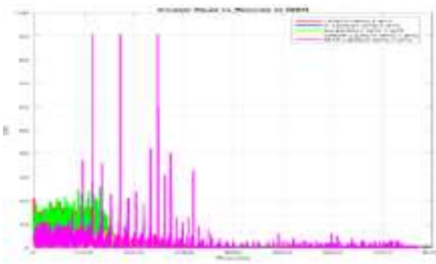

Figure 8: Cluster Head Vs Rounds in WSN

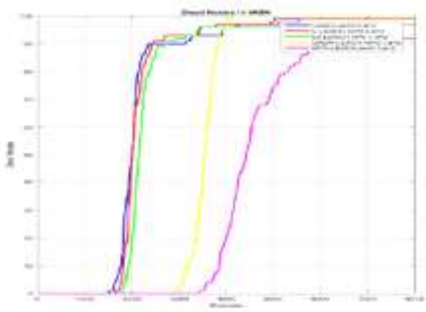

Figure 9: Network Lifetime Comparison of different protocols (at energy $E_0 = 0.4J/Node$)

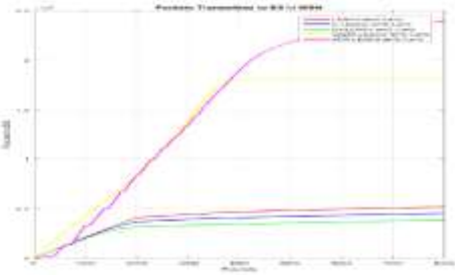

Figure 10: End to End Delays

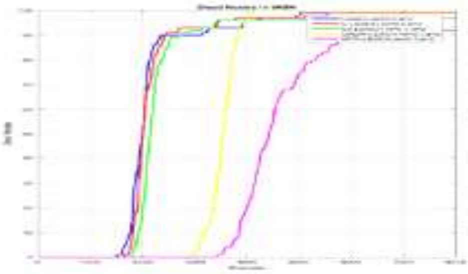

Figure 11: Dead Nodes in WSN

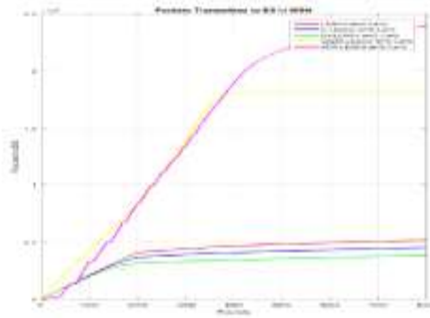

Figure 12: Packet Transmitted to BS in WSN

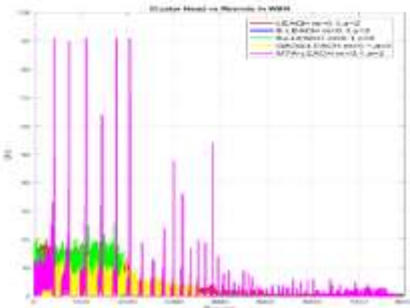

Figure 13: Cluster Head Vs Rounds in WSN

Above graph shows the Cluster Head Selection in multiple rounds with Energy 0.4J/node.

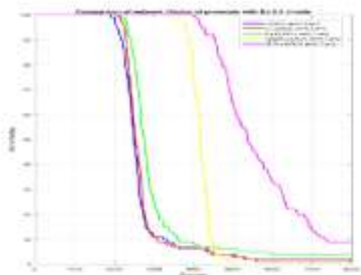

Figure 14: Network Lifetime Comparision of different protocols (at energy $E_0 = 0.5J/Node$)

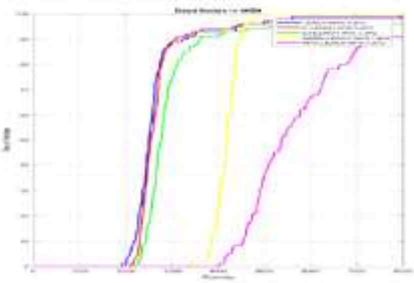

Figure 15: Dead Nodes in WSN

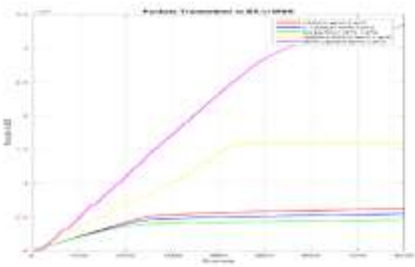

Figure 16: Packet Transmitted to BS in WSN

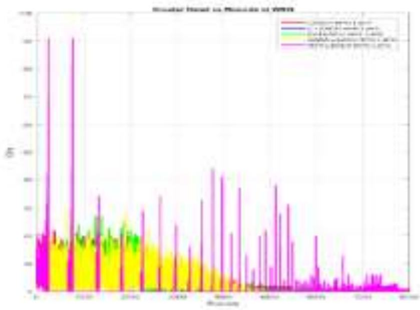

Figure 17: Cluster Head Vs Rounds in WSN

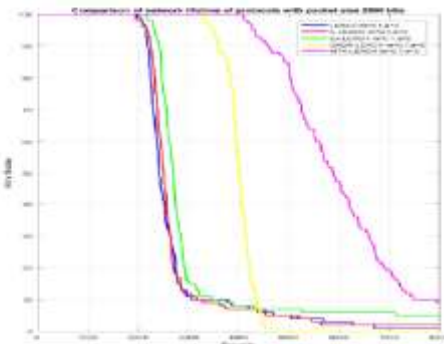

Figure 18: Network Lifetime Comparison of different protocols with packet size is of 2000 bits

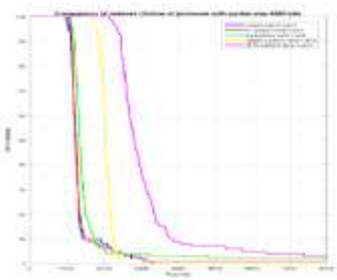

Figure 19: Cluster Head variations in multiple Rounds for different protocol with packet size 4000 bits in WSN

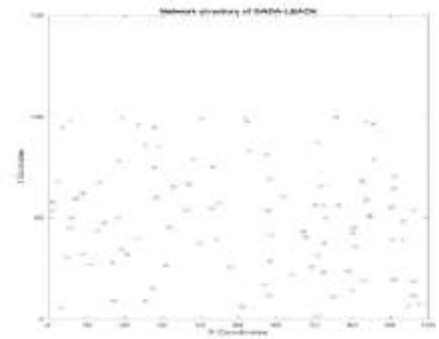

Figure 20: Network Structure of GADA-LEACH

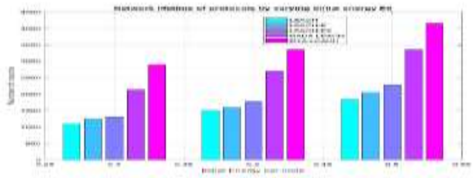

Figure 21: Network Lifetime of different routing Protocol by varying initial energy E_0

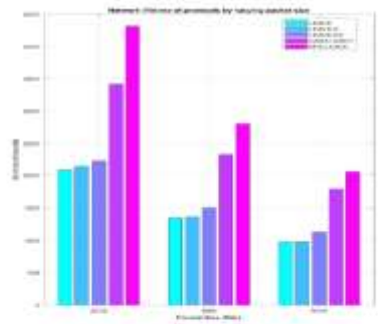

Figure 22: Network Lifetime of different number of rounds Protocols by varying packet size

X. CONCLUSION

The results of this paper show improvement in energy This paper presented the comparison of network lifetime of nodes in wireless sensor network by using different routing protocols. In this work the network lifetime is enhanced by using Multitier LEACH, protocol using hard threshold and soft threshold. The Network lifetime of nodes are compared for different routing protocols with different energy level and with different packet sizes.

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