WSN Lifetime Enhancement using Advanced Multitier (AMT) Leach Protocol: A Survey

Ritu Pandey, Mr. Shyam Shankar Dwivedi

Abstract—**Energy is the prime factor for nodes in Wireless Sensor Network (WSN), which can't be restore when once introduced. To improve the network lifetime, progressive routing is utilized. Right now intend to improve arrange lifetime by utilizing Multitier Advance LEACH based protocol by considering leftover energy and separation of nodes in WSN. The grouping Algorithm is a kind of fundamental method used to improve arrange lifetime. It can raise the versatility of the system. energy productive bunching conventions is develop for the properties of heterogeneous wireless sensor networks. We propose and assess another Multitier Advance LEACH convention which is the mix of dispersed energy effective grouping plan for heterogeneous remote sensor systems, (DEEC) and Threshold Sensitive Energy Efficient convention (TEEN). In DEEC, plot the cluster-heads are picked by a likelihood dependent on the proportion between leftover energy of every node and the normal energy of the remote sensor organize. The timeframe of a group sets out toward nodes is relies upon the their underlying and residual energy. The cluster head is chosen a node having high starting and remaining energy than the nodes with low energy. Concussively, the reproduction results show that AMT-LEACH accomplishes prolonged lifetime and more noteworthy reminder than existing significant clustering plans in heterogeneous conditions.**

Keywords: Wireless sensor networks (WSNs) Leach, Genetic algorithm, LEACH, E-LEACH, LEACH-EX, GADA-LEACH, Advanced Multitier LEACH, and Network lifetime.

I. INTRODUCTION

Wireless sensor systems are assortments of minimized size and generally reasonable computational nodes that measure neighborhood natural conditions or different parameters and forward such data to the base station for suitable processing. The essential unit in a sensor arranges is a sensor node. Wireless sensor systems can detect the earth, speak with neighboring nodes and can likewise perform essential calculations on the information being gathered. Late improvements in sensor innovation and remote correspondence have helped in the sending of huge scope Wireless sensor systems for an assortment of utilizations including ecological observing of living space, information assortment of temperature, pressure, sound, dampness, light, vibration and so on. For such kind of uses hundreds or thousands of ease sensor nodes can be sent over the zone to be checked. In information gathering sensor organize every sensor node should occasionally report its detected information to the sink. celebrated in light of the fact that it is simple and sufficient. Filter breaks the total system into numerous groups, and the run time. The sensor nodes are generally powered by small inexpensive batteries. Therefore energy consumption should be managed in an efficient way to maximize the post deployment network lifetime. On the off chance that there is long distance between the sensor and sink, transmission isn't energy proficient since the transmission power is relative to the square or fourfold of the transmission separation. Multihop steering is performed than sensor to sink direct transmission for long separation as more energy could be spared. Yet, multihop steering cause abuse of the nodes near the sink and make them come up short on energy rapidly. In this manner unequal energy utilization [18] is a significant issue in direct transmission and multihop steering plans. It can cause early crumple of the system because of the passing of some basic nodes which brings about noteworthy decrease of system lifetime. Every node sends its information to the sink with no transfer in direct transmission mode and this mode helps in keeping away from the hand-off weight for the nodes near the sink. In bounce by jump transmission mode every node advances the information to its next level bounce neighbors and this aides in lessening the weight of long separation transmission for nodes far away from the sink. Consequently even energy utilization among all nodes can be acquired by appropriately assigning the measure of information transmitted in the two modes. A energy cost work has been utilized in [19] which thinks about beginning energy, lingering energy and the necessary transmission energy along the course. In altered bellman portage calculation [20] course with least expense is chosen from every single accessible course in an iterative way. Diverse battery levels in a grouping directing are appointed to the nodes in [21].

In this paper, we propose the Multitier Advance LEACH (DEEC +TEEN) protocol and analyze the performance of the many clustering algorithms for network lifetime improvement 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.

Among the several routing protocols proposed for WSNs, Multitier Advance LEACH algorithms are more effective in meeting WSNs requirements, mainly Network Lifetime [22-25]. 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

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have applied this concept, i.e., LEACH [7], TEEN [8], and LEACH-EX; however, AMT 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.

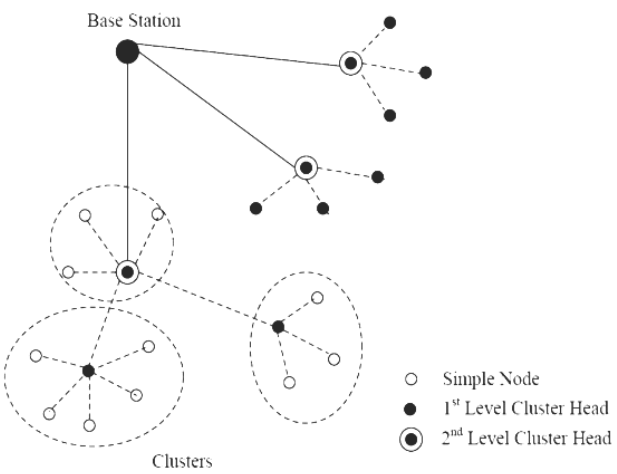

Figure 1: Cluster-based Model

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 sends 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 frequently gathered into individual disjoint sets called a cluster, bunching is utilized in

WSNs, as it gives arrange adaptability, asset sharing and effective utilization of obliged assets that gives organize topology solidness and energy sparing properties. Clustering plans offer diminished correspondence overheads, and productive asset portions in this way diminishing the general energy utilization and decreasing the obstructions among sensor nodes. A sensor node can versatile by amassing the sensor nodes into bunches for example bunches. Each cluster has a pioneer, regularly alluded to as the bunch head (CH). A CH might be chosen by the sensors in a bunch or pre¬ allotted by the system fashioner. The cluster enrollment might be fixed or variable. WSN is huge scope systems of little installed gadgets, each with detecting, calculation and correspondence abilities. They have been broadly examined lately. Various bunching calculations have been explicitly intended for WSNs for versatility and proficient correspondence. The idea of bunch based directing is likewise used to perform energy productive steering in WSNs. In a various leveled design, higher energy nodes (cluster heads) can be utilized to process and send the data while low energy nodes can be utilized to play out the detecting.

A large number of clusters will congest the area with small size clusters and a very small number of clusters will exhaust the cluster head with large amount of messages transmitted from cluster members. LEACH protocol is hierarchical routing based on clustering and find the optimal number of clusters in WSNs in order to save energy and enhance network lifetime.

We are given some clustering Advantages:

1. Clustering reduces the size of the routing table stored at the individual nodes by localizing the route set up within the cluster.
2. Clustering can conserve communication bandwidth since it limits the scope of inter cluster interactions to CHs and avoids redundant exchange of messages among sensor nodes.
3. The CH can prolong the battery life of the individual sensors and the network lifetime as well by implementing optimized management strategies.
4. Clustering cuts on topology maintenance overhead. Sensors would care only for connecting with their CHs.
5. A CH can perform data aggregation in its cluster and decrease the number of redundant packets.
6. A CH can reduce the rate of energy consumption by scheduling activities in the cluster.

IV. LEACH PROTOCOL

Low-Energy Adaptive Clustering Hierarchy (LEACH) [15] [16] is one of the grouping based various leveled routing protocols. It is utilized to gather information from wireless system. In the system, hundreds/a huge number of remote sensors are scattered that gathers and transmit information. In these sensor nodes the cluster head's are chosen. Since sensor nodes have low energy source and battery can't be supplanted once conveyed, the odds of node demise situation is more. So we require LEACH protocol to expand the lifetime of system. Drain convention utilizes arbitrary selection cluster head choice and cluster arrangement. Here the energy is equitably appropriated by turning the cluster head in each round. Filter convention is partitioned into 2 stages:

Threshold is given by

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

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.

2) Steady-state phase: This 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.

LEACH algorithm has the following Advantages:

• The hierarchy, routing information and path selection are relatively simple, and the SNs do not need to store large amounts of routing information, and do not need complex functions. The CH node is randomly selected, the opportunity of each node is equal, and the load of whole network is balance [17]. However, there are a number of disadvantages in LEACH protocol, such as:

• Because the CHs in LEACH protocol are randomly generated, energy consumption can be evenly distributed in the network. However, it does not consider residual energy of sensor nodes. Therefore, it is possible for a sensor node that has low residual energy to be selected as a CH. This can render the cluster useless due to the quickly exhausted battery power of the CH.

• On the other hand, LEACH does not examine the distance between sensor nodes and the BS. Consequently, if the geographic position of the CH is far from the BS and the geographic position of the CM is far from their CH, it will consume a lot of energy sending and forwarding data. 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:

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

$$T(n) = 0 \qquad \forall n \epsilon G \qquad (1)$$

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.

$$E[\#CH] = \sum_{i=1}^{N} P_i(t) * 1 = k. \quad (2)$$

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

$$P_i(t) = \begin{cases} \frac{k}{N-k*\left(r mod \frac{N}{k}\right)} & : \quad C_i(t) = 1 \\ 0 & : \quad C_i(t) = 0 \end{cases} \quad (3)$$

$\sum_{i=1}^{N} C_i(t)$ 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.

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

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

Cluster Formation Algorithm:

1. Cluster Heads broadcasts an advertisement message (ADV) using CSMA MAC protocol. ADV = node's ID + distinguishable header.
2. Based on the received signal strength of ADV message, each non-Cluster Head node determines its Cluster Head for this round (random selection with obstacle).
3. Each non-Cluster Head transmits a join-request message (Join-REQ) back to its chosen Cluster Head using a CSMA MAC protocol. Join-REQ = node's ID + cluster-head ID + header.
4. Cluster Head node sets up a TDMA schedule for data transmission coordination within the cluster.
5. TDMA Schedule prevents collision among data messages and energy conservation in non cluster-head nodes.

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 node i 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. GADA-LEACH

The proposed energy proficient convention GADA-LEACH depends on GA and separation mindful directing. Right now, is registered by utilizing parameters, for example, energy all things considered, energy of cluster heads, separation of CH with its related nodes, number of nodes in cluster, separation of base station from all CH's and number of CH's shaped. The whole progression of GADA-LEACH is appeared in Fig 3. The means of the proposed calculation are depicted beneath:

1. The parameters on which the system execution depends are to be introduced in the initial step.
2. At that point the energy parameters which incorporate beginning energy of sensor nodes, energy to run transmitter and beneficiary, information accumulation and intensification energy are introduced in the subsequent advance.
3. The underlying populace for the cluster head determination is created. The cluster heads are chosen from some number of nodes present in the system.
4. In the subsequent stage, after the age of beginning populace, the wellness of every node is assessed for the better outcomes with the goal that as well as can be expected be chosen as cluster head. Our wellness work incorporates energy parameters, separation of CH with related nodes and separation of BS from CH's. Wellness work utilized is as per the following,

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

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

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

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

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. 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.

VII. 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.

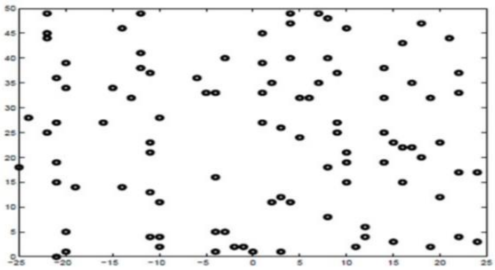

Figure 2: 100-node random network

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 as supposed in [36].

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 are m N advanced nodes equipped with initial energy of E0 (1 + a), and (1 - m) N normal nodes equipped with initial energy of E0.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.

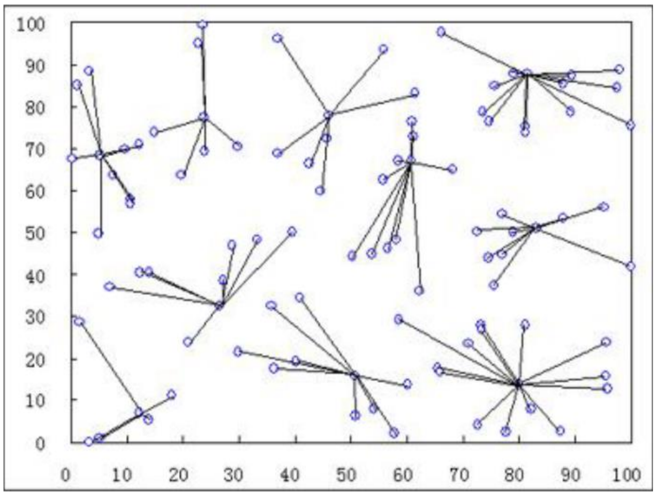

Figure 3: Dynamic cluster structures by DEEC algorithm

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. These protocols are described 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 ni denote the number of rounds to be a cluster-head for the node si, and we refer to it as the rotating epoch. In homogenous networks, to guarantee that there are average Popt 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 ni 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 pi = 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. (3), 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

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

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

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

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

where G is the set of nodes that are eligible to be cluster-heads at round r. If node si has not been a cluster-head during the most recent ni rounds, we have si 2 G. In each round r, when node si 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 (si), the node si becomes a cluster-head during the current round.

Note the epoch n_i is the inverse of pi. From Eq. (4), ni is chosen based on the residual energy Ei(r) at round r of node si as follow

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

where n_{opt} = 1/popt denote the reference epoch to be a cluster-head. Eq. (7) 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 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 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. (4), ni 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. (7) shows that the rotating epoch ni 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. (4), we can see that Popt 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 Popt to be the reference point of pi. 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 popt with the weighted probabilities given in Eq. (8) for normal and advanced nodes [9].

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

Therefore, pi 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. (9) for pi on (6), 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. (10)

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

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. (10) and (11), $I_i = \left(N + \sum_{i=1}^{N} a_i\right)/p_{opt}N(1+a_i)$ 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. (9) and (11), the average energy E(r) is needed to compute the average probability pi. It is difficulty 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. (4) and (7), 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

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

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. (7), considering E(r) as the standard energy, DEEC controls the rotating epoch ni 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. (12), 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

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

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:

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

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:

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

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

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

$$k_{opt} = \frac{\sqrt{N}}{\sqrt{2\pi}} \sqrt{\frac{\in_{fs}}{\in_{mp}}} \frac{M}{d^2_{toBS}} \quad (24)$$

Z_{M-j} =Substituting Eqs. (16) and (17) into Eq. (15), we obtain the energy E_{round} dissipated during a round. Thus we can compute the lifetime R by (13). In Fig. 2, using the parameters described in Table 1, we show the value of analytical lifetime when a and m are changed. 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 Etotal and estimate value R of lifetime to all nodes. When a new epoch begins, each node si will use this information to compute its average probability pi by Eqs. (12) and (11). Node s_i will substitute pi into Eq. (6), and get the election threshold T (s_i), which is used to decide if node si should be a cluster-head in the current round.

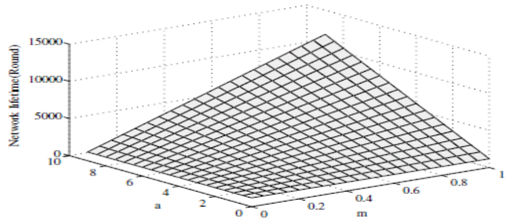

Figure 4: Estimation of Network Lifetime

called worst case relay selection. If the PU pair stops and selects a suitable cooperative relay more quickly when observing the SU candidate relays based on an observation order denoted by S1 compared with another observation order denoted by S2,say that the order S1 is more efficient than the order S2.

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.

VIII. CONCLUSION

This paper displayed the Analysis of network lifetime of nodes in wireless sensor network by utilizing distinctive steering conventions. Right now arrange lifetime is improved by utilizing Multitier LEACH, convention utilizing hard edge and soft edge. The Network lifetime of nodes are contrasted for various steering conventions and diverse vitality level and with various parcel sizes.

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