Heterogeneous WSN Advanced Energy Optimization Protocol based on Node Energy: A Survey

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Abstract— **Wireless Sensor Networks (WSNs) are the fastest-growing technology, with applications ranging from environment monitoring to traffic flow prediction to eavesdropping to research and academic disciplines. Due to the random deployment of sensor nodes in a wireless environment, security metrics have emerged as the most promising challenge that communication wireless networks face today.**
To optimize the life cycle of heterogeneous wireless sensor networks (WSNs), the stable election protocol (SEP) is an upgraded algorithm of the Low Energy Adaptive Clustering Hierarchy (LEACH). The uneven energy consumption of cluster heads and nodes, on the other hand, would reduce the lifetime. On the one hand, include node energy in cluster head election to reduce cluster head energy consumption; on the other hand, lower node energy consumption in the cluster through indirect transmission by intermediate nodes. SEP is a heterogeneous-aware protocol that extends the time interval before the first node dies (what we call the stability period), which is critical for many applications where sensor network feedback must be dependable. SEP is based on the weighted election probabilities of each node to become cluster head depending on its remaining energy. When comparing the LEACH protocol and the SEP protocol with the enhanced Efficient-SEP protocol using the suggested algorithm by MATLAB, the results reveal that the enhanced E-SEP protocol works well in balancing the energy consumption to improve the lifetime.

Index Terms— Heterogeneous wireless sensor networks Efficient Stable Election Protocol, greeting routing, election probability

I. Introduction

As an emerging application area for ad hoc networks, wireless sensor networks (WSNs) have gotten a lot of interest. WSNs are made up of a group of sensor nodes that are low-power, low-cost, and multifunctional, as well as having wireless processing and communication capabilities. These sensors communicate over a short distance using a wireless medium and work together to accomplish a similar goal, such as environmental monitoring, target tracking, and industrial process management [1]. The idea is to use a group of small, inexpensive fixed sensors to sense physical properties about the surroundings and then communicate them to a sink node [2]. Despite the diversity of WSN applications, the primary function of WSNs is to sense data, process it, and transmit it back to a specific node (base station or sink).

The expanding computational capacity of WSN technology necessitates that these sensor nodes be more prepared to handle more sophisticated functions. During the deployment of a base station in a sensor network, energy conservation, sensor node coverage, and reliability challenges are addressed. Base stations are typically believed to be static, although in some circumstances, they are assumed to be mobile in order to collect data from sensor nodes.

As a classic technique in clustered routing protocols, the LEACH [3] protocol is a Low-Energy Adaptive Clustering Hierarchy protocol. The cluster head node is chosen in a random loop to balance the energy consumption of nodes within the network, and it is clustered based on the signal intensity received by the node. The Stable Election Protocol (SEP), a heterogeneous aware protocol, was proposed in [4]. It is based on weighted election probabilities of each node to become cluster head based on their individual energy. This method ensures that cluster heads are chosen at random and dispersed based on the fraction of energy consumed by each node, ensuring that the nodes' energy is used uniformly.

The SEP [4] algorithm is a type of LEACH-based heterogeneous network clustering routing technique. The SEP algorithm takes an energy heterogeneous approach, increasing the likelihood of high-level nodes becoming cluster heads based on the beginning energy of distinct sets of different cluster election probabilities, so that high-level nodes and ordinary nodes die at the same time. However, the SEP algorithm still has an uneven cluster head distribution, a large number of nodes in the cluster, and no consideration for the node's leftover energy. Clustering is a promising strategy for extending the life of WSNs. Right now, I'd like to look into another, more potent strategy based on the Improved-SEP procedure and other comparable enhancement strategies.

The remainder of the paper is laid out as follows. Starting with a review of the literature in Section II, we go over LEACH in detail in Section III. Section V Efficient SEP Concept was described in Section IV SEP. Finally, Section VI brings the paper to a close.

II. Literature Review

A literature survey analyses old data and generates a mix of new and old data. As a result, this part contains a brief explanation of numerous research papers as well as the presence of research paper summary and synthesis.

Smaragdakis et al. [5] are known for a LEACH variant called the Stable Election Protocol (SEP). It is primarily intended for dual-level heterogeneous networks with doublet types of sensors (particularly Advance and normal nodes). Advance sensors, on average, retain more energy and must be turned CHs more frequently than conventional nodes. The CHs chosen here refer to the starting energy of the sensor. The biggest drawback is that the CH's choice is not dynamic. As a result, advanced nodes that are far away from the sink waste their energy more quickly and eventually cease to exist. For a multilayer heterogeneous network, SEP is ineffective.

SEP has been enhanced, according to Malluh et al. [6]. Advanced nodes are also chosen as CHs more frequently than regular sensors. The number of nodes connected to each CH is also taken into account. As a result, the sensor nodes can be distributed evenly throughout the CHs. EM-SEP also chooses the higher energy sensor as a CH if there are more than one sensor available to be a CH at a given round. These two elements lengthen the sensor network's stable time. The fundamental disadvantage of this strategy is that it ignores the expense of inter-cluster communication.

Stable Election Protocol (SEP) is a heterogeneous-aware protocol proposed by Georgious et al. [7] to extend the stability period and average throughput. SEP is based on the residual energy-weighted election probabilities of nodes to become CH. Nodes are classified into two groups based on their energy levels: advanced nodes and regular nodes. The energy of advanced nodes is higher than that of typical nodes. Advanced nodes have a higher chance of becoming cluster heads than standard nodes.

The Stable Election Protocol (SEP), a heterogeneous aware protocol, was proposed in [7]. It is based on weighted election probabilities of each node to become cluster head depending on their individual energy. This method ensures that cluster heads are chosen at random and dispersed based on the fraction of energy consumed by each node, ensuring that the nodes' energy is used uniformly. The SEP analysed two types of nodes (two tier in-clustering) and two level hierarchies. The LEACH [8] protocol, which maintains the Integrity of the Specifications like a standard clustering technique, performs badly in the heterogeneous WSN.

The SEP protocol [9] is based on the LEACH protocol, which delivers varied electoral cluster head probabilities for nodes with different energy levels and works better in the heterogeneous WSN than LEACH. However, on the one hand, SEP does not adjust cluster head election probability in real time based on the node's residual energy, causing some nodes to become cluster heads prematurely, reducing their lifetime; on the other hand, nodes in the cluster transfer information directly to the cluster head, storing a problem that the energy consumption of the edge nodes is far awry. The transmission path between the cluster head and the base station must also be optimised.

The usefulness of the SEP protocol in heterogeneous WSN is demonstrated in [10], as well as the drawbacks of the unbalanced energy consumption in cluster nodes and the inflexibility of the cluster head election procedure. In [12], greedy routing is used to solve the energy-efficient transmission information routing path from cluster head to base station, resulting in a reduction in energy usage.

III. LEACH SCHEMES

One of the most common clustering algorithms for WSN is the Low-Energy Adaptive Clustering Hierarchy [11]. It's a design that's tailored to a certain application. In LEACH, nodes form local clusters, with one node serving as the cluster leader and the others as member nodes. When the cluster head receives data from all member nodes, it performs signal processing tasks on the data (e.g., data aggregation) and sends it to the remote BS. As a result, being a CH node consumes significantly more energy than being a member node.

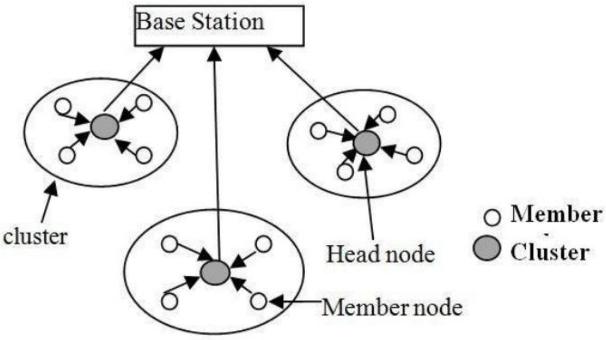

Figure 1: LEACH System

LEACH's major goal is to use rotation to select sensor nodes as cluster heads. As a result, the energy burden of being a cluster head is dispersed evenly across the nodes. LEACH's operation is broken into rounds. A set-up phase precedes the steady state phase in each round. Clusters are organised during the setup phase, and data is sent to the BS during the steady-state phase. CH is initially chosen based on the signal energy of the nodes.

As CH, the nodes with the highest energy are chosen. Each sensor node n creates a random number between 0 and 1 and compares it to a threshold T that has been set (n). The sensor node becomes CH in that round if randomT (n), otherwise it is a member node. Where P represents the desired percentage of CHs, r represents the current round, and G represents the set of nodes that have not been elected as CHs in the previous 1/ P rounds. LEACH is a completely distributed technique that does not require any network global information. LEACH can ensure not only that each node has the same probability as CH, but also that the network nodes' energy consumption is relatively balanced. In Figure 2, the LEACH display procedure is depicted.

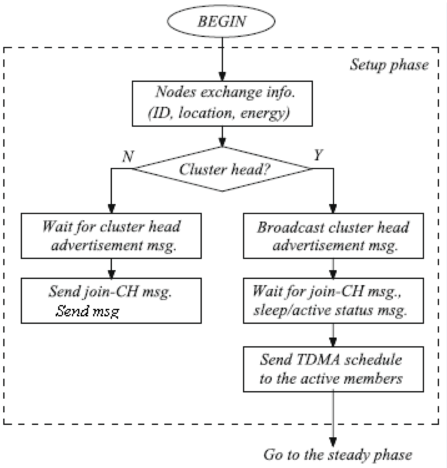

Figure 2: LEACH Protocol Process

IV. Analysis of SEP Algorithm

G. Maragdakis proposed the SEP [12] method as a traditional heterogeneous network clustering routing technique. Using the second energy heterogeneous network, this agreement is built on the LEACH protocol, with the initial energy isomorphism of this element added. The network is separated into ordinary nodes and high-level nodes based on their diverse properties, and each has a different cluster election probability, with high-level nodes having a higher cluster election probability than ordinary nodes. So that high-level nodes and regular nodes die at roughly the same time, extending the network cycle's stability.

The SEP routing protocol is a two-level initial energy heterogeneous WSN cluster protocol that includes two types of energy nodes: common nodes and advanced nodes. The SEP protocol's main idea is to compute the cluster head election probability of nodes based on their starting energy and then change the cluster head nodes in a random round manner. As a result, all sensor nodes may share network load and reduce network power loss, extending the network's lifetime.

A. Cluster Establishment Stage

It is assumed that the initial number of nodes is n, and the nodes are divided into common nodes and advanced nodes. Among nodes, the optimized cluster head ratio is P_{otp}. The initial energy of the common node is E_0. The energy of the advanced node is 1+α times of common node that is $(1+\alpha)\ E_0$.

The total node proportion of the advanced node is m, so the total energy of the whole heterogeneous WSN is as follows [9]:

$$n(1-m)\ E_0 + nm\ (1+\alpha)\ E_0 = n(1+m\alpha)\ E_0 \quad (1)$$

Cluster heads have a higher energy demand than others because they are in charge of coordinating activities amongst clusters and transmitting data to base stations. As a result, the responsible cluster head is constantly cycled, ensuring that the SEP protocol consumes the same amount of energy. According to the computing likelihood, each node determines whether or not it may be a cluster head in the current wheel. Each sensor node chooses a value between [0 1] at random and compares it to the T(i) threshold. The node can be elected as a cluster head if the value is less than T(i); else, it will not be.

The LEACH algorithm is still used in the SEP algorithm, which is a random selection cluster head mechanism. The clustering mechanism determines whether or not to join the cluster based on the signal strength received from the cluster head node through the non-cluster head node. As a result, the cluster head is not evenly distributed, and the number of nodes in the cluster is random due to the clustering mechanism.

The election probability in the SEP algorithm is only related to the node's initial energy, not its residual energy; after the network has been running for some time, the residual energy of the high-level node may differ from that of the ordinary node, and the probability of becoming the cluster head is still higher than that of the ordinary node. This affects the network's overall survival time by hastening the demise of some advanced nodes. When the SEP algorithm is employed in single-hop transmission mode, nodes that are far away from the cluster head nodes must use a lot of energy to carry out long-distance information transmission, causing network nodes to die prematurely and shortening the network life cycle.

B. Transmission Stage

After the cluster is built, the members of the cluster communicate with the cluster head nodes in the allocated time slot to complete the transmission of the data collected in the corresponding area. The cluster head determines the allocation time slot by sending Time Division Multiple Address (TDMA) scheduling table, and the cluster nodes are in the dormancy state of the non-transmission slot which is one way of SEP protocol to save energy. After receiving the data, the cluster head converges and compresses with its own data and sends it to the sink node.

V. Improved Efficient-SEP Protocol

Regarding the inadequacies of SEP referenced above,we present the nodes residual energy to partake in the edge computation to alter probability of turning out to be cluster headsof nodes within time. The interlude nodesin clusterare additionally presented, so cluster nodescan transmitthe apparent data.

A. *Energy Consumption Model*

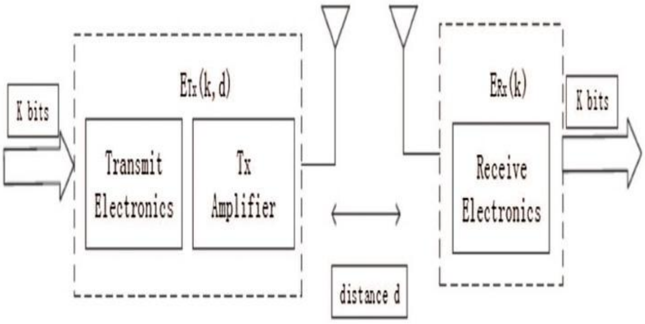

Figure3: Energy Consumption Model

In record, energy utilization of accepting or sending k bit data whendistance d is presented.
Supplicant time

$$E_T(k,d) = \begin{cases} E_{elec}\,k + E_{fs}\,kd^2 & d < d_0 \\ E_{elec}\,k + E_{mp}\,kd^4 & d > d_0 \end{cases} \qquad (2)$$

Accepting time

$$E_R(k) = E_{R-elec}(k) = E_{elec}\,k \quad (3)$$

$E_{elec}$is energy dissipated of the transmission a unit of data; $E_{fs}$and $E_{mp}$is energy dissipated for gain magnifying; d_0 is threshold distance.

B. *Cluster Head Election Method*

By just presuming the initialenergy can't settle unbalanced energy utilization wonder by SEP.So nodes residual energy join the estimation of cluster headelection perspective to build WSN life cycle. On a basic level, the node with very less residualenergy hassmaller chance to be clusterhead, in order to adjust the energy utilization among nodes and life cycle enhancement.
The node residual energy is E_r; and total residual energy is Es; andenergy referencefactor is E_c.

$$E_c = e^{-(E_r - \frac{E_S}{n})} \qquad (4)$$

Mentioning to original SEP cluster head election procedure, node residual energy is integrated as energy reference factor E_c. As in SEP, the initial energy for normal nodes is Eo, and for advanced nodes, $Eadv$= 1+αEo.
Assume for intermediate nodes, E_{int}= 1+μ Eo.
We have: μ= α/2
Our probability setting $popt$ remains the same. However, the total initial energy of the system is increased by the introduction of both advanced and intermediate nodes:

$$n\cdot E_o(1-m-b) + n\cdot m\cdot E_o 1+\alpha + n\cdot b\cdot(1+\mu) = n\cdot E_o(1+m\cdot\alpha+b\cdot\mu) \quad (5)$$

Where n is the number of nodes, m is the proportion of advanced nodes to the total number of nodes n with energy more than the rest of the nodes and b is the proportion of intermediate nodes. The overall energy of the network is increased by a fraction of (1+$m\cdot\alpha$+$b\cdot\mu$) and the new epoch of the system must be equal to $Popt\cdot$ (1+$m\cdot\alpha$+$b\cdot\mu$).
E_c is the energy reference factor taken from, equation no.4, if we choose P_{nrm}, P_{int} and $P_{adv}$for probabilities of becoming normal, intermediate and advanced nodes respectively. Hence we have:

$$P_{nrm} = P_{opt}/(1+m\cdot\alpha+b\cdot\mu)*E_c \ (6)$$
$$P_{int} = (P_{opt})\times(1+\mu)/(1+m\cdot\alpha+b\cdot\mu)*E_c \ (7)$$
$$P_{adv} = (P_{opt})\times(1+\alpha)/(1+m\cdot\alpha+b\cdot\mu)*E_c \ (8)$$

To guarantee that the sensor nodes must become cluster heads as we have assumed above, we must define a new threshold for the election processes, referring back to Eq. (5). The threshold (n_{nrm}),(n_{int}), $T(n_{adv})$ for normal, intermediate and advanced respectively becomes:

$$T(n_{nrm}) = \begin{cases} \frac{P_{nrm}}{1-P_{nrm}[r \times mod(1/P_{nrm})]} & if\ n_{nrm} \in G' \\ 0 & otherwise \end{cases} \quad (9)$$

From above we have n×1$-m-b$in normal node, which ensures that our assumption (1) is exact.
Where G' is the set of normal nodes that has not become cluster head in the past $1/P_{nrm}$ round r, the same analogy follows for the intermediate and advanced nodes,

$$T(n_{int}) = \begin{cases} \frac{P_{int}}{1-P_{int}[r \times mod(1/P_{int})]} & if\ n_{int} \in G'' \\ 0 & otherwise \end{cases} \quad (10)$$

We have $n \times b$ intermediate nodes; with G'' as the set of intermediate nodes that has not become cluster head in the past $1/P_{int}$ round r.

$$T(n_{adv}) = \begin{cases} \frac{P_{adv}}{1-P_{adv}[r \times mod(1/P_{adv})]} & if\ n_{adv} \in G''' \\ 0 & otherwise \end{cases} \quad (11)$$

We have $n \times m$ advanced nodes; with G''' as the set of advanced nodes that has not become cluster head in the past $1/P_{adv}$ round r.

From Eq. (9), (10), and (11), the average total number of cluster heads per round will be:

$$n \cdot (1-m-b) \times P_{nrm} + n \cdot b \times P_{int} + n \cdot m \times P_{adv} = n \times P_{op} \quad (12)$$

This gives us the same number of cluster heads compared with the original LEACH setting. However, because of the heterogeneity energy setting, energy dissipation is better controlled.

C. Intermediate Node Mechanism

SEP protocol does not optimize the data transfer between the members of the cluster, and the member nodes in the cluster transfer the information to the cluster heads directly. So, it will spend higher energy transfer information and shorten the lifetime of the network greatly for the edge nodes that are far away from the cluster head. Therefore, in this case, joining the intermediate nodes will obviously improve the adverse effects of the edge nodes and balance the energy consumption of each node.

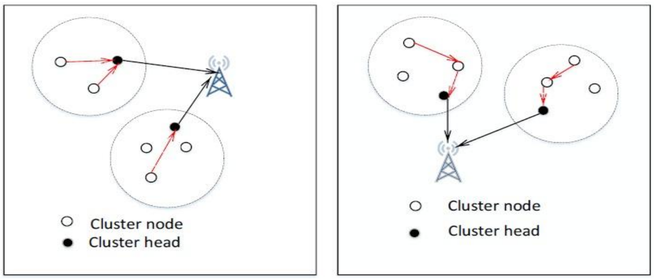

Figure 4: Direct compares indirect transmission

The principle of the intermediate node mechanism is that the nodes in the cluster use the intermediate nodes to transmit the information indirectly so as to reduce their energy consumption and prolong their life. After cluster structure is formed, the cluster node i computes the energy consumed E_1 that transmits information indirectly through other nodes in this cluster. We select the node with the smallest E_1 as the Intermediate node of node i. Compare E_1 with E_i which the energy consumption of direct transmission. If $E_1 < E_i$, the node i transmits indirectly through the intermediate nodes; otherwise, the node transmits directly.Figure 4 is the comparison between direct transmission and indirect transmission in a cluster. Part (a) shows the direct transmission in a cluster and part (b) shows the indirect transmission in a cluster.

VI. CONCLUSION

The Stable Election Protocol (SEP) is described in this paper. A SEP sensor node in a heterogeneous two-level hierarchical network elects itself as a cluster leader based on its starting energy relative to that of other nodes. SEP is dynamic in the sense that no prior distribution of the various levels of energy in the sensor nodes is assumed. Furthermore, our Efficient SEP analysis is not simply asymptotic, i.e. it applies equally well to small and large networks. Finally, SEP is scalable since it does not require precise knowledge of each node's position in the field.

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