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Non-Energy Efficient Clustering (NEEC) Wireless Sensor Networks

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Abstract: Nodes in a wireless sensor network (WSN) may sense their environment, process data, and communicate wirelessly with one another. Energy awareness is a key design concern for WSNs, and as a result, several protocols have been developed specifically for routing, power control, and data transmission. Among the most important methods for cutting down on power use is the clustering algorithm. It has the potential to extend the network's life and make it more scalable. The feature of heterogeneous wireless sensor networks necessitates the development of clustering techniques that are energy efficient. We present and assess NEEC, a new approach to clustering that is both innovative and energy efficient for WSNs with heterogeneity. The nodes in NEEC are created at random within a predetermined square area. In the first round, the cluster leaders are chosen based on the Euclidean distance between the nodes, which assumes that the nodes are initially homogenous. In subsequent rounds, the nodes are treated as diverse and the cluster leaders are chosen according to the remaining energy of each node. Cluster leaders are more likely to be nodes with high initial and residual energies compared to nodes with lower energies. In conclusion, NEEC accomplishes a longer lifespan and more effective message transmission, according to the simulation findings.

Keywords: Diversity in the natural environment, conservation of energy, and WSNs

1. Introduction

A wireless sensor network (WSN) is a system of interconnected, autonomous devices dispersed over a physical space that use sensors to collectively detect and report changes in variables including motion, noise, vibration, temperature, and pollution [1]. Countless nodes in this network collect information from an inaccessible location and relay their findings to a central processing unit, or "sink," for analysis. Keep frequent and long-distance transmissions to a minimum to extend the network lifetime[2, 4]. This is because sensor nodes are power-constrained devices. Therefore, it is not recommended that nodes communicate directly with the base station. Separating the network into smaller groups and having each group choose a single node to act as their leader is one efficient method [6]. Data is gathered by the cluster head from all of the sensors in the cluster, fused, and then sent to the base station. Consequently, certain nodes are needed for long-distance transmission while the other nodes are needed for short-distance transmission only. This results in greater energy savings and a longer lifespan for the network as a whole. Electing cluster leaders at regular intervals is the basis of several energy-efficient routing systems [11], [7]. Broadcast and data query are two areas where these methods may be very successful [10], [5]. Clustering is the foundation of DEEC [8], a distributed energy-efficient clustering method for heterogeneous wireless sensor networks. The likelihood of electing cluster-heads is dependent on the ratio of each node's residual energy to the network average energy. Each node's starting and residual energies determine the round number of its spinning epoch. DEEC adjusts the node's spinning epoch according on its energy. Cluster leaders are more likely to be nodes with high initial and residual energies compared to nodes with lower energies. Because of its heterogeneous aware clustering technique, DEEC is able to increase the lifespan of the network, particularly the stability period. Created by the DDEEC [3], implemented by the Distributed

Power Saving Clustering enables a more equitable distribution of network nodes based on their remaining energy for cluster head selection. Therefore, in the first transmission rounds, the advanced nodes are mainly asked to be chosen as cluster leaders. After their energy levels drop reasonably, they will be given

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the same chance of being elected as cluster heads as the regular nodes. Choosing CH in BEENISH [9] is based on the nodes' residual energy level relative to the network's average energy, which is the same idea as in DEEC. But regular nodes and advance nodes are the foundation of DEEC. Normal, advance, super, and ultra-super nodes are the four categories of nodes used by BEENISH.

Here is how the rest of the paper is structured. We quickly go over relevant literature in section 2. In Section 3, the algorithm's network configuration is detailed. The specifics of the NEEC algorithm that was suggested are presented in section 4. The outcomes of the simulation are detailed in Section 5. The report concludes with a discussion on the scope of future work.

2. 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. In this protocol, 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 p_i to be p_{opt} can ensure that there are $p_{opt}N$ cluster-heads every round and all nodes die approximately at the same time. If nodeshave different amounts of energy, p_i of the nodes with more energy should be larger than p_{opt}. Let $\bar{E}(r)$ denote the average energy at round r of the network, which can be

obtained by $\bar{E}(r) = 1/N \sum_{i=1}^{n} E_I(r)$ To compute $\bar{E}(r)$, each node should have the knowledge of the total energyof all nodes in the network. They calculate the optimal cluster-head number that they want to achieve. They getthe probability threshold, that each node s_i use todetermine whether itself to become a cluster-head in each round, as follow:from the increase of total energy caused by increasing of m and a. The stability period of LEACH keeps almost the same in the process. Being an energy-aware protocol, DEEC outperforms other clustering protocols. Especially when a is varying, DEEC obtains 20% more number of round than LEACH-E.

3. Network Setup

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

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 n_i rounds, then there is a possibility for it to become a cluster head. In each round r, when nodes_i finds it is eligible to be a cluster-head, it will choose a random number between 0 and 1. If the number is lessthan threshold $T(s_i)$, the node s_i becomes a cluster-head during the current round. The epoch n_i is the inverse of p_i. n_i is chosen based on the residual energy $E_i(r)$ at round r ofnode s_i 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.

They evaluated the performance of DEEC protocol using MATLAB. For they considered a wireless sensor network with N = 100 nodes randomly distributed in a 100m X 100m field and assumed the base station is in the center of the sensing region. To compare the performance of DEEC with other protocols, they ignore the effect caused by signal collision and interference in the wireless channel. The radio parameters used in their simulations are shownin Table 1.

Table 1: Parameters used in simulations

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Parameter	Value
Eelec	5 nJ/bit
εfs	10 pJ/ bit/m^2
εmp	0.0013 pJ/bit/m^4
E_0	0.5 J
EDA	5 nJ/bit/message
d_0	70 m
Message size	4000 bits
popt	0.1

The protocol compared with DEEC include LEACH, SEP, and LEACH-E. In multi-level heterogeneous networks, theextended protocols of LEACH and SEP. They examined several performance measures under two-levelheterogeneous networks and observed the performance of LEACH, SEP, LEACH-E, and DEEC. And have shownthe results of the case with m = 0.2 and a = 3, and the results of the case with m = 0.1 and a = 5. It is obvious thatthe stable time of DEEC is prolonged compared to that of SEP and LEACH-E. SEP performs better than LEACH. But the unstable region of SEP is also larger than DEEC protocol. It is because the advanced nodes die more slowly than normal nodes in SEP. They increased the fraction mof the advanced nodes from 0.1 to 0.9 and a from 0.5 to 5 and compared the number of round when the first node dies. They observed that LEACH takes few advantagesIn our proposed algorithm we consider the network setup used in DEEC, which consists of N nodes, which are uniformly dispersed within a M X M square region. The network is organized into a clustering hierarchy, and the cluster-heads collect measurements information from cluster nodes and transmit the aggregated data to the base station directly. Moreover, we suppose that the network topology is fixed and no-varying on time. We assume that the base station is located at the center. We consider two- level heterogeneous network consisting of m - advanced nodes each with initial energy $E_o(1+a)$ and N – m, normal nodes each with the initial energy E_o. The total initialenergy of the heterogeneous networks is given by:

$$E_{total} = mE_o(1+a) + (N-m) E_o$$

The energy expended by the radio to transmit an L-bit message over a distance d is given by:

$$E_{tx}(L; d) = LE_{elec} + LE_{fs}d^2 \text{ if } d < d_0 LE_{elec} + LE_{mp}d^4 \text{ if } d \geq d_0$$

where E_{elec} is the energy dissipated per bit to run the transmitter (E_{TX}) or the receiver circuit (E_{RX}). The E_{elec} depends on many factors such as the digital coding, the modulation, the filtering, and the spreading of the signal. E_{fs} and E_{mp} depend on the transmitter amplifier model used, and d is the distance between the sender and the receiver. For the experiments described here, both the free space (d^2 power loss) and the multi path fading (d^4 power loss) channel models were used, depending on the distance between the transmitter and the receiver. If the distance is less than a threshold, the free space (fs) model is used; otherwise, the multi path (mp) model is used. In DEEC they have fixed the value of d_0 randomly as d_0 = 70. But in our proposed algorithm we are calculating the value of d_0 using the concept of Euclidean distance between the nodes.

Given a network of n nodes we are interested inidentifying the clusters of nodes along with their cluster heads. Our algorithm starts with random generation of n nodes in a fixed square region. Basically it is assumed that each and every node can communicate to the base station and to all other nodes in the network. The square region selected is subdivided into squares of equal side and the distances between the center of each sub square and all other nodes in that sub square are calculated. The node whose distance is minimum

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is selected as the cluster head of the nodes belonging to that sub square. The clusterheads are connected to the base station and hence all the n nodes of the network will have a unique path for communication with the base station through their

orresponding cluster head. NEEC is implemented using the same parameters used in DEEC.

4. NEEC Algorithm

In this section, the proposed NEEC algorithm is presented which consists of two modules. In the first module, the generation of the nodes, cluster formation and initial routing in the network are achieved. In the second module,node which is to communicate with the base station is received as an input and the path through which the communication takes place is identified. The initialenergies to the nodes are given in two categories as normalnode and head node. The energy calculations are done as similar to the DEEC. The cluster heads to the subsequent round are selected according to the residual energies of thenodes.

Algorithm: Module I

Input: $N \rightarrow Number\ of\ Nodes, S \rightarrow User\ Selected\ Node$
Output: $Graph\ Plot\ of\ Nodes\ \&\ Clusters.$
Procedure:
$BaseStaion(x, y) = (\frac{Side}{2}, \frac{Side}{2})$
$Location_x = rand(1, N), Location_y = rand(1, N)$
$Side = Range/4$
$if\ (Location_x > Side)\ \&\&(Location_x \leq Side)\&\&(Location_y > Side)\&\&\ (Location_y \leq Side)$
$Spot\ the\ Cluster$
$minimum_x = \min(Location_x)$
$maximum_x = \max(Location_x)$
$minimum_y = \min(Location_y)$
$maximum_y = \max(Location_y)$
$center = \frac{maximum_x + minimum_x}{2}, \frac{maximum_y + minimum_y}{2}$
$distance = \sqrt{(Location_x - center(x))^2 - (Location_y - center(y))^2}$
$HeadNode(x, y) = \min distance Location_x, Location_y$
$Connect: \forall\ HeadNodes \rightarrow BaseStation$

Algorithm: Module II

Input: $N \rightarrow Number\ of\ Nodes, S \rightarrow User\ Selected\ Node$
Output: $Graph\ Plot\ of\ Nodes\ \&\ Clusters.$
Initialize: $E_0, \alpha, E_{da}, E_{Elec}, E_{mp}$
Procedure:
$BaseStaion(x, y) = (\frac{Side}{2}, \frac{Side}{2})$
$Location_x = rand(1, N), Location_y = rand(1, N)$
$Side = Range/4$

$if\ (Location_x > Side)\ \&\&(Location_x \leq Side)\&\&(Location_y > Side)\&\&\ (Location_y \leq Side)$
$Spot\ the\ Cluster$
$minimum_x = \min(Location_x), maximum_x = \max(Location_x)$
$minimum_y = \min(Location_y), maximum_y = \max(Location_y)$
$center = \frac{maximum_x + minimum_x}{2}, \frac{maximum_y + minimum_y}{2}$
$distance = \sqrt{(Location_x - center(x))^2 - (Location_y - center(y))^2}$
$headNode(x, y) = \min_{Location_x, Location_y} distance$
$Connect: \forall\ headNodes \rightarrow BaseStation$
Initialize: $Energy_{FreeNode} = E_0, Enery_{HeadNode} = E_0(1 + \alpha)$
$d_{toCH} = \frac{M}{\sqrt{2 * \pi * k}}$
$d_{toBS} = 0.765 * \frac{M}{2}$
$Energy_{CH} = E_0 - L * (2 * E_{Elec} + E_{mp} * d^4_{toBS} + E_{da})$
$Energy_{BS} = E_0 - L * (2 * E_{Elec} + E_{mp} * d^2_{toBS})$
$While\ GET\ NODE\ FROM\ USER$ % Repeat it until user stops
Trace path of the transaction
$Subtract\ Energy\ of\ that\ Node$
$if\ Energy\ of\ Location_x(S), Location_y(S) < threshold$
$Isolate: Location_x(S), Location_y(S)$
end

5. Simulation Results

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The above algorithm is coded using MATLAB and tested for different user input values for the number of nodes. Figure1(a) is the clustered network of 30 nodes whose cluster heads are connected to the base station, in which any node can communicate to the base station through its cluster head. Figure 1(b), depicts that there is a transaction takes place between node 11 and the base station through the cluster head 12. Similarly, Figure 2(a) and Figure 2(b) are the networks of 75 nodes. Module II is also coded using the same parameters used in DEEC. Accordingly, the energies of the nodes will be reduced using the calculations explained in the algorithm.

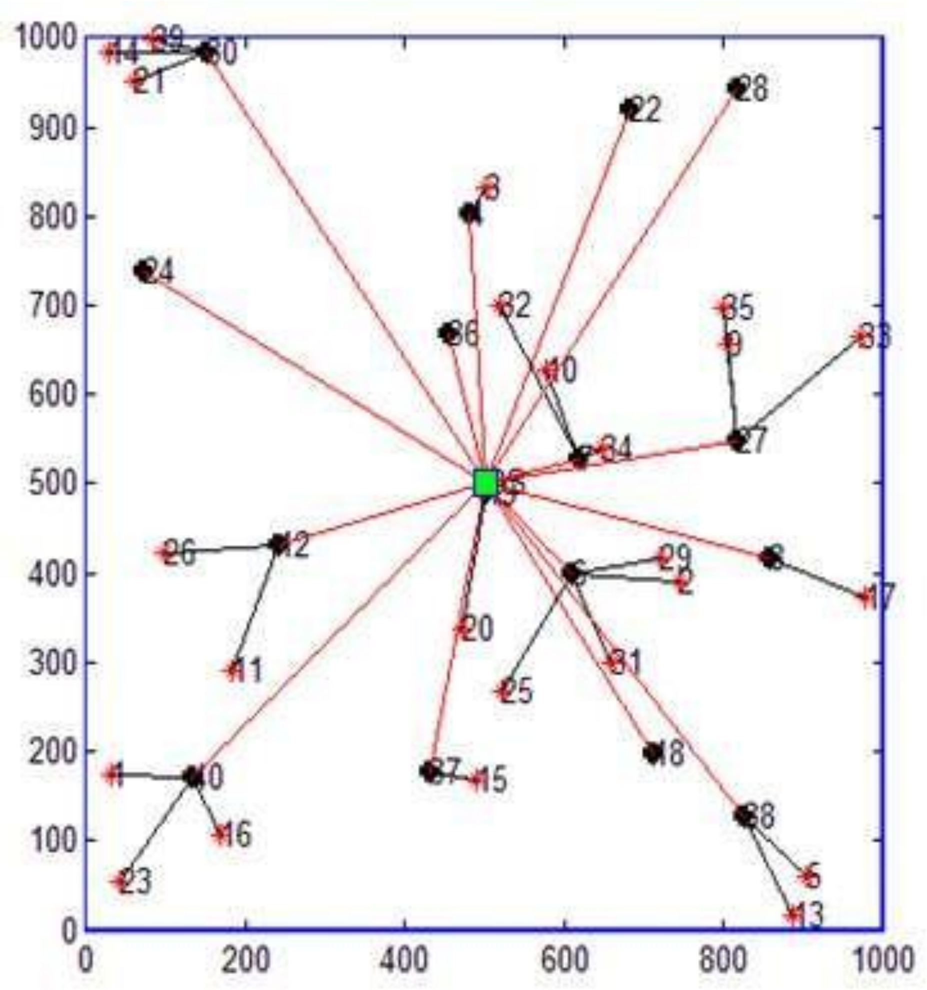

Figure 1(a)
A network with N=30

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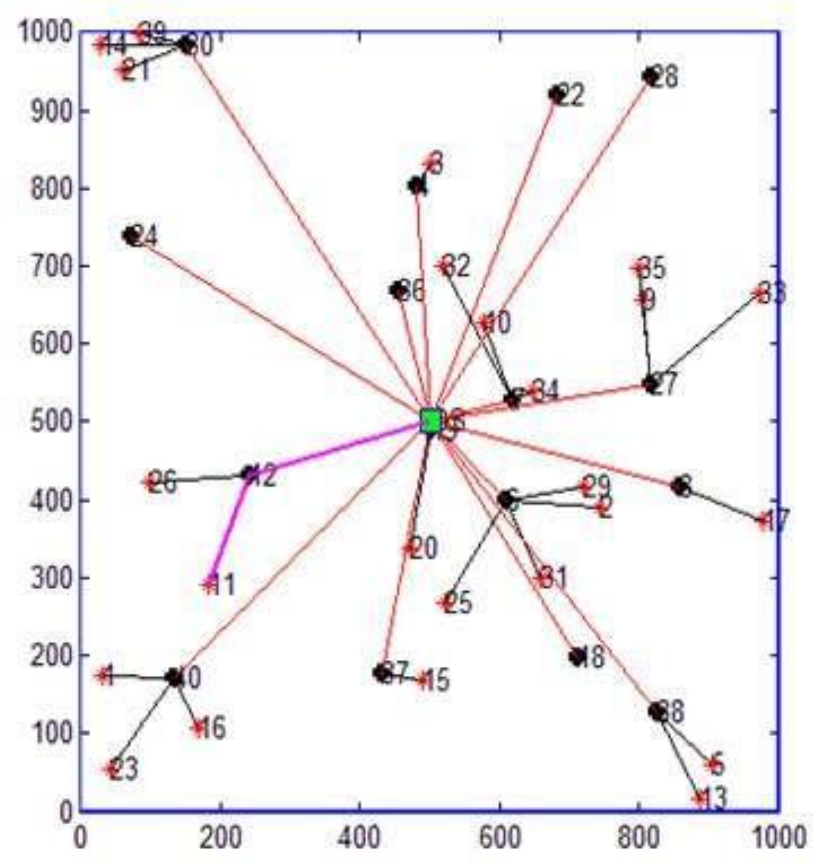

Figure 1(b)
Network of N=30 with transaction

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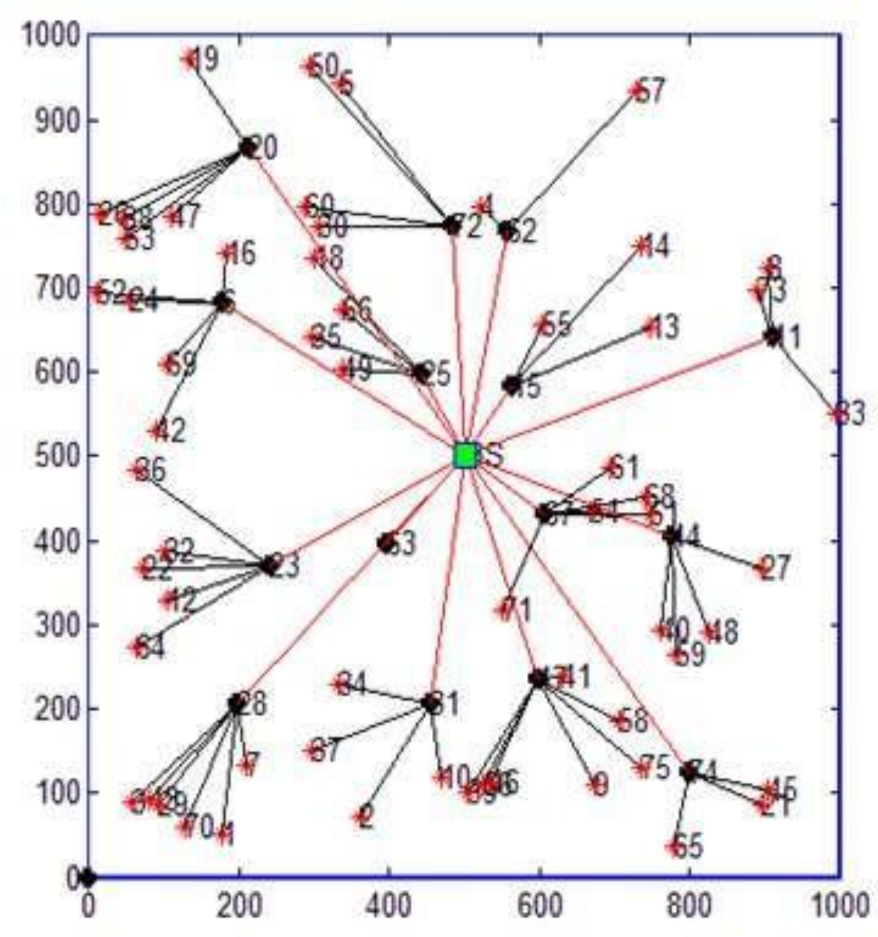

Figure 2(a)
A network with N=75

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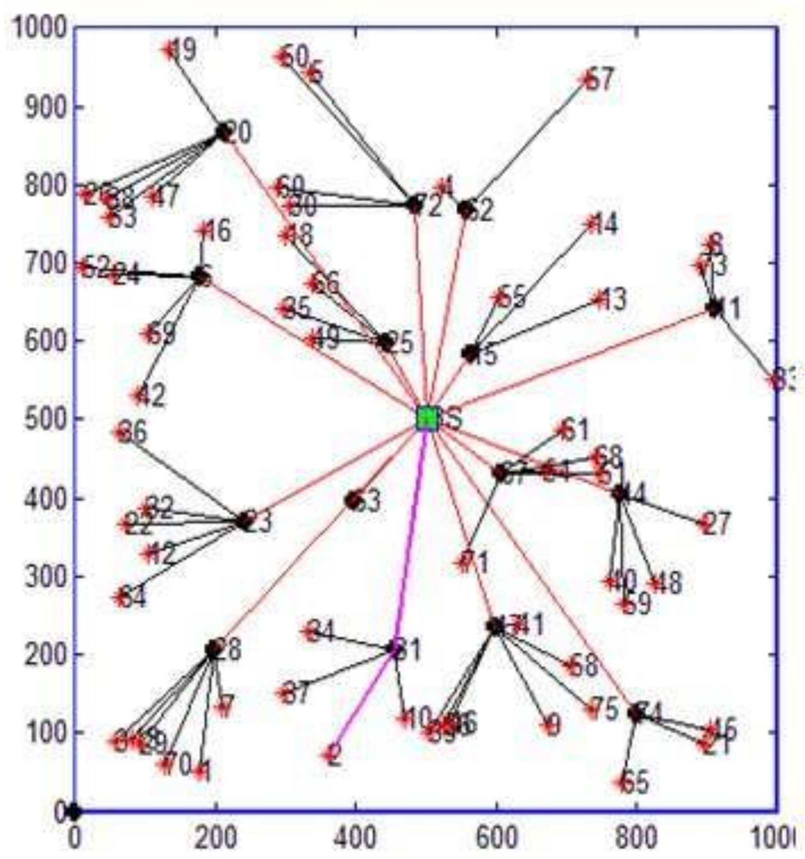

Figure 2(b)
Network of N=75 with transaction

6. Conclusion

We provide a new method for clustering heterogeneous wireless sensor networks that uses less energy. At the outset, our suggested approach treats all nodes as identical, and it uses the Euclidean distance to group them into clusters and identify the cluster head. In order to get comprehensive network routing information, cluster heads are linked to the base station. Then, two types of energies are used to initialize the nodes: one for the head nodes and one for the normal nodes. The nodes' remaining energies are used to identify new clustering and cluster heads after a transaction. We use MATLAB to simulate the proposed NEEC method. It is also possible to compare our algorithm to others already in use, such as DEEC and DDEEC, and to confirm its efficacy.

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