NODE RECOVERY ALGORITHMS FOR WIRELESS SENSOR NETWORK

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Abstract

Wireless Sensor Networks (WSN) is built with the purpose of monitoring distant areas in a variety of settings and using a variety of applications. The primary challenges that the WSN faces are those of energy efficiency and fault recovery. The WSN calls for fault node recovery and clustering that is efficient with energy in order to make the most of the energy supply device that is comprised of battery-powered sensors and increase the network's lifespan. Therefore, the purpose of this research is to build a hybrid method using K-means clustering in order to lower the amount of energy that is used by WSN sensors and to increase their lifespan. The hybrid algorithm is a method that incorporates both fault node recovery and energy efficient clustering techniques into a single solution. Utilizing Grade Diffusion (GD) in conjunction with the Genetic Algorithm allows for the discovery of fault nodes to be carried out (GA).. The proposed method is carried out on the MATLAB platform, and it is contrasted with the existing methods, which include Low-Energy Adaptive Clustering Hierarchy (LEACH), Hybrid Hierarchical Clustering Approach (HHCA), Novel Energy Aware Hierarchical Cluster (NEAHC), and Heuristic Algorithm for Clustering Hierarchy Protocol (HACH), in terms of the amount of energy that is wasted, the amount of energy that is consumed, and the amount of received. The Extending of the Useful Lives of Wireless Sensor Networks When a sensor node is powered off, the Fault Node Recovery Algorithm is put into use. The success of the Fault Node Recovery Algorithm is contingent on the success of the Generic Algorithm and the Grade Diffusion Algorithm. Because of the method, there may be a reduction in the number of sensor node replacements and an increase in the number of routes that are reused. This algorithm also increases the number of active nodes, while simultaneously lowering the rate of data loss and the amount of energy that is used.

***Keywords**: Energy efficient, grade diffusion, fault node, sensors, genetic algorithm, energy consumption*

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1. INTRODUCTION

In recent years, research pertaining to Wireless Sensor Networks (WSN) has become increasingly popular due to their inherent benefits and potential for compensation in a variety of applications, including but not limited to weather forecasting, intelligent transportation systems, vehicle detection, industrial performance measurement, health control and intelligent management, and environmental monitors [1]. The WSN is made up of sensor nodes, each of which is a combination of a variety of very small electrical components and has a limited battery life. In addition, sensors are the most important component of the network structure, which functions autonomously and without the knowledge or involvement of human monitoring. In addition to having processing and memory capabilities, the sensors also have access to energy, which is perhaps the most crucial factor in extending the network's lifespan [2].

The performance of a WSN may be negatively impacted by a wide variety of issues, including deployment, location, connection, coverage, measurement, software, and hardware [5]. The failure of each node in the WSN poses the challenge of not satisfying the quality requirements in addition to the performance constraints. In order to boost the efficiency of the WSN, the issue in question has to be resolved and fixed. The battery life is increased, and the undesired energy consumption of the fault node is decreased, when such issues are solved [6, 7]. In WSN, fault node recovery is the primary objective, with the secondary goals of improving overall behavior and boosting overall performance. Therefore, fault recovery and making the network as energy efficient as possible are the two primary problems in the WSN [8]. When it comes to mobile node networks, the base station is the one in charge of ensuring that the amount of energy that is supplied to the network is not limited. In the event that the node has a malfunction, the energy may be delivered by the base station to the node [9, 10]. It is essential to prevent the supply of energy that is not required in order to lengthen the nodes' lifespans.

In Wireless Sensor Networks, the goal is to offer communication that is successful in terms of both energy efficiency and cost. The suggested technique, which is dependent on Grade diffusion algorithm paired with the genetic algorithm, extends the amount of time that a sensor node may remain operational after it has been turned off. The algorithm's potential outcomes include the replacement of sensor nodes and an increase in the number of routes that are reused. This algorithm also increases the number of active nodes while simultaneously lowering the rate of data loss and the amount of energy that is used.

The following is a suggested outline for the layout of the paper: section 2 will be devoted to a review of the current works related to energy clustering scheme and fault node recovery. The proposed fault node recovery strategy is explained in depth in section 3, which contains the relevant information. In section 4, the outcomes of the implementation together with the performance metrics of the suggested approach are reported. The conclusion of the research is offered in section 5, along with its potential future applications.

2. LITERATURE REVIEW

The researchers have created a variety of failure node replacement methods that may be used in WSN. Several of the works are discussed in detail in this article.

Seema Dahiya *et al.* [16] With the purpose of balancing the energy routing in the WSN, we introduced the Self-Organizing Cluster based Greedy best first search Opportunistic routing (SOCGO) protocol. The protocol was developed based on the four distinct phases that are used in WSN to maintain the energy routing. These phases include the death phase, the guard phase, the active phase, and the sleep phase. In order to get the best detection rate, the hybrid K-means with greedy best search method was used. This algorithm analyzed the neighbouring nodes in order to find consumers for the remaining energy. The coverage that had been lost due to the presence of coverage gaps might be recovered thanks to the use of the opportunistic routing algorithm. The solution that was described successfully restored the coverage hole pairs and recovered the hole pairs, which contributed to an increase in the network's lifespan. Both a heterogeneous and a homogeneous environment were used to successfully implement the provided technique.

Sercan Yalcin *et al.* [17] have created an improvement to mobile fault detection in WSN that was influenced by bacterial genetics. The voltage value was utilized to determine whether or not there was a problem, and it was determined using bacteria. The sensor nodes that are a part of the WSN are able to deliver data packets to the cluster head that consist of health information at predetermined intervals. The procedure that was described served as the basis for the selection of the cluster head. The mobile sinks acquired information on the health stage from all of the full nodes on their way to the cluster head through the intersection pivot. After finishing this phase, with the help of a mobile sink, data packets were collected. In addition, software and hardware problems inside the WSN were identified and replaced, which improved the condition of the nodes that are still active within the WSN.

Somaye Jafarali Jassbi *et al.* [18] have developed a clustering technique known as Hybrid Energy-Efficient Distributed Clustering (HEED) in order to increase the energy efficiency of the WSN. In the method that was described, the HEED and the sleep/wakeup approach were applied to WSN in order to improve the amount of emery that was eaten. The identification of the cluster failure node served as the basis for the selection of the backup cluster head. It was decided to choose the fault node, and then the member nodes were used to replace it. The weighted median method was used to determine which of the cluster head nodes should serve as the fault node. In addition to isolating the faulty node, the nearby node was used to replace it by switching from sleep state to active mode. This brought the system back online.

Karl E.Prikopa *et al.* [19] have provided fault tolerant least squares solvers in a way that is based on WSN chatting. In the over determined linear systems, the linear least squares problem (also known as dLLS) was addressed by using the GLS-IR (Gossip-Based Least Squares Solver) computer programme. Normal equations and semi-normal equations are the two variations that were developed using the approach that was provided before. The aforementioned two different options were integrated via iterative improvement in combined precision, which not only helped to maintain the system's stability but also brought down the amount of money spent on communication. The method that is based on gossip was employed in the communication of each node that regulates the communication of each mode of its subsequent neighborhood. This was done in the context of distributed aggregation. As a result, the method that was supplied instantly had a flaw that might be substituted with the neighbouring nodes.

Usha Mohanakrishnan *et al.* [20] have proposed the modified cognitive tree routing protocol, also known as MCTRP, together with the Genetic Whale Optimization Algorithm in order to make WSN and VANETs more energy efficient. The most important purpose of the network was to realize its potential for efficient transmission. The cars served in the capacity of transmitting nodes in the network. The technique known as cognitive radio helped to identify the spectrum in order to make more effective use of the occupied channels across all of the nodes. A routing protocol that provides a tree-based structure for networks that have efficient routing is included in the system that has been shown here. When it came time to choose the root channel for the transmission, the genetic algorithm combined with the whale optimization method was supported. The use of the evolutionary algorithm in conjunction with whale optimization resulted in an improvement to the routing protocol. In order to allocate the spectrum family according to effective channel utilization, the routing protocol was utilized.

3. PROPOSED MODEL OF WSN

This study presents a method for wireless sensor networks (WSNs) that is based on a combination of the ladder diffusion algorithm and the genetic algorithm. Figure 1 presents the flow chart for your perusal. In this implementation, the ladder diffusion algorithm is used to route paths for data relay and transmission in wireless sensor networks. This helps to reduce the amount of power consumed as well as the amount of processing time required to build the routing table, while simultaneously preventing the generation of circular routes. In addition, in order to guarantee the security and dependability of data transmission, the ladder diffusion algorithm creates backup routes. This helps to prevent the loss of power and processing time that would otherwise be incurred during the process of rebuilding the routing table in the event that some sensor nodes are absent. During the operation of the wireless sensor network, the suggested method calculates the number of sensor nodes that are not functional, and it then calculates the parameter Bth according to figure 1.

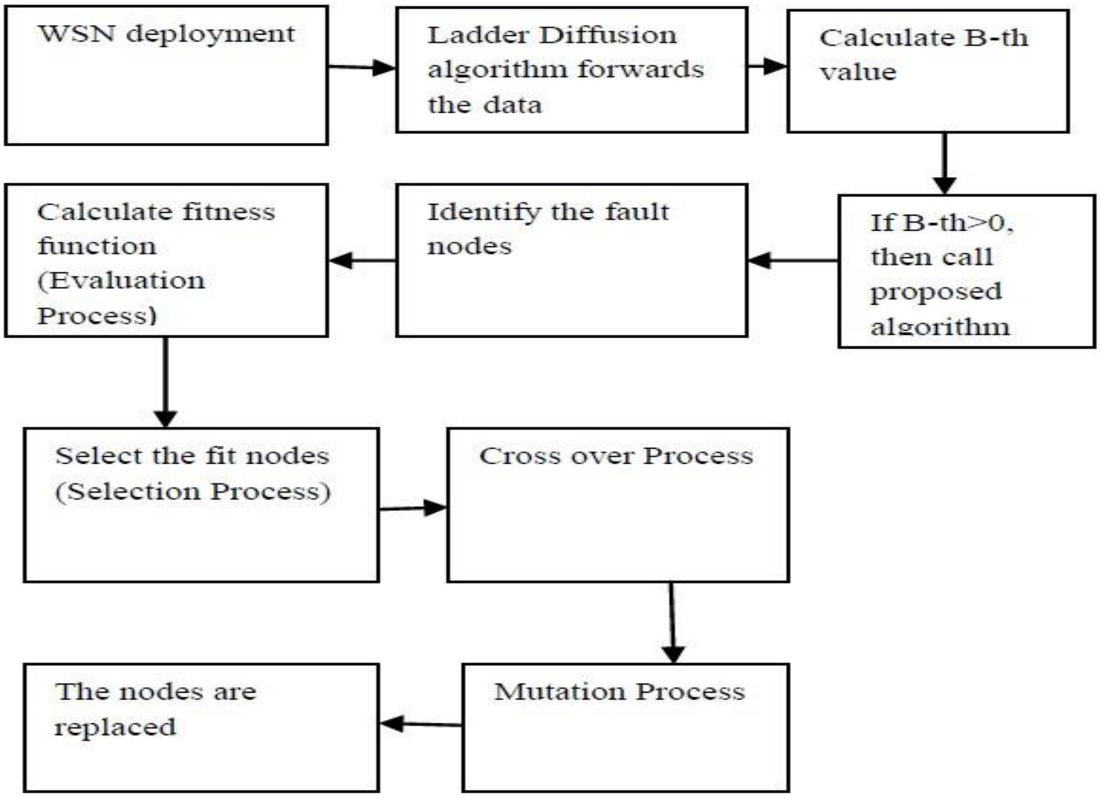

Figure 1: Proposed Architecture in Fault Node recovery

Using the ladder diffusion technique, the algorithm in Figure 1 generates the grade value, routing table, a set of neighbour nodes, and payload value for each sensor node. This is shown in the figure as a ladder. When events take place, the data pertaining to those occurrences are sent from the sensor nodes to the sink node in accordance with the LD algorithm. After that, the suggested method determines B_{th} by calculating it according to (1). In the event that B_{th} is greater than zero, the algorithm will be activated, at which point it will replace sensor nodes that are not performing properly with functional nodes chosen by the genetic algorithm. If the operators of the wireless sensor network are ready to continue replacing sensors, the network will be able to continue functioning.

Network Model:

A number of nodes make up the network model that is included inside the sensing region. In the model of the network that has been presented, there are one hundred nodes spread out across an area that is fifty meters by fifty meters. These particular nodes are known as the static nodes in the network. In order to make the network model more understandable, several assumptions were developed and are described below.

In this particular network, the wireless connection method is used to contact all parties involved in the communications process. If both of the nodes in question are situated inside the communication range, then the wireless connection between them can function properly. The TDMA is supported inside the planned WSN. The Sink Node may be chosen from among the other 100 nodes in the WSN network, which has high energy and is based on grade value. Utilizing the GD technique allows for the detection of the failure node inside the network models.

Fault Node Recovery Algorithm

To prevent unnecessary energy consumption in the various applications, such as event monitoring, the WSN relies on the replacement of fault nodes. Combining genetic algorithm, this study created the GD algorithm. By eliminating the faulty node or hub in the WSN, the suggested solution decreases data packet loss and extends the useful life of the remaining nodes.

This article presents a fault node recovery method that is built using GD in conjunction with the genetic algorithm. Within the WSN, the GD algorithm is responsible for establishing the payload value, neighbour nodes, routing table, and grade value for each sensor node. During the operation of the WSN, the computation of the fault node or the sensor nodes that are not functioning properly is made possible by the GD algorithm. It is possible to calculate the fault node based on the calculation of the parameter B^{th}, which is computed in the equation below.

$$B^{th} = \sum_{a=1}^{MAX\{G\}} T^a \qquad (1)$$

$$T^a = \begin{cases} 1 & \frac{M_a^{Pre}}{N_a^{Ref}} < \alpha \\ 0 & otherwise \end{cases} \qquad (2)$$

Where, M_a^{Pre} can be referred as the number of sensor nodes presently operating time based grade value, B^{th} can be referred as the sensor node grade value a in addition, the N_a^{Ref} can be represented as the number of sensor nodes with grade value. In the grade value computation, α parameter can be represented as the value among 0 and 1. The number of sensor node operate for each grade value is less than α, that condition T^a should be 1 in addition B^{th} is considered as the larger than zero.

GA based Optimal Path Selection

The GA algorithm is used in this situation to search for a substitute for the fault node and to allow the optimum route selection procedure. Chromosomes are used as the parameters in the GA, and their encoding takes the form of a binary structure. Alterations are made to the binary strings in order to enhance or diminish the fitness value, which is believed to be the genes. It is recommended that the fitness function be interpreted as the replacement of the fault node with the mathematical behavior of optimum route selection. The fitness function is able to be improved by using the GA optimization procedure, which is available. The genetic algorithm (GA), along with each of its rounds, computes fitness values in relation to chromosomes. Initialization, Fitness function, Selection, crossover, and Mutation are the five stages of operation that the GA is capable of doing. Other stages include crossover.

Step 1: Initialization

During this stage, an initial count of the chromosomes that will be considered for each solution is carried out. The number of chromosomes that are associated with the size of the population may be initialized by the user. The length of the chromosome is used to refer to the number of sensor nodes that are included inside the chromosome, which also holds the mixing solutions. The genes in the GA are represented as either a 0 or a 1, with a 1 representing a fault node that needs to be replaced and a 0 representing a healthy node that does not need to be replaced.

For Initialization: Here, the chromosome length is taken as 20 already discussed, gene have the value 0 or 1. The chromosomes values are initialized in the random condition. In the proposed methodology, we are considered the 5 number of node not functioning.

Step 2: Fitness function

Because it is impossible to contribute genes freely to the fitness function in the process of fault node replacement and route selection, the best path may be chosen during the fitness assessment. This allows for the path selection process. Therefore, the primary purpose of the GA algorithm that we have presented is to replace the fault sensor nodes in addition to reusing the selection of the frequent pathways. Therefore, the sensor nodes that are not functional are replaced, and optimum pathways are calculated using the fitness function, which is provided in the following sentence,

$$F^N = \sum_{a=1}^{MAX\{G\}} \frac{P^a \times tp^{-1}}{N^a \times tn^{-1}} \times a^{-1} \tag{3}$$

Where, tp can be defined as the total amount of optimal paths selection in the WSN, tn can be defined as the total amount of sensor nodes in the WSN, P^a can be defined as the sensor node reused paths based on their grade value and N^a can be defined as the replaced sensor nodes based on their grade value of a.

Step 3: Selection

The selection process may get rid of the genes that don't contribute much to fitness while keeping the ones that do. Using an elitist selection method, only the genes that are the most beneficial to the organism are kept in the chromosomes. After the crossover process, the genes with the lowest fitness values are eliminated, and those with the highest fitness values are introduced. As soon as the lowest fitness value has been removed, the process advances to the crossover phase.

Step 4: Crossover

At each crossing stage, certain chromosomes swap places with one another. In order to generate new chromosomes, chromosomal modifications occur through a mechanism based on a single point of reference. The mating pool has enough chromosomes to produce two children. The crossover point in the parents may be chosen from the end to the beginning of the gene sequence. The crossing point is joined and traded as each fraction advances on either side. The crossover frequency may be set independently of the fitness values and is instead linked to a random number generator.

Step 5: Mutation

During the mutation stage, the GA's rapid convergence slows down and new characteristics are developed that were not present in the starting population. In this procedure, the gene is discarded at random in the chromosomes.

4. RESULT ANALYSIS

When both the energy and grade values are high, the GD method may be used to determine which node will serve as the sink. The black circle in Figure 4 represents the sink node. That node has the most energy and highest grade value estimated based on the GD method and is thus fixed as a sink node among the network model's 500 nodes. Improving the application monitoring time and extending the lifespan of sensors are both possible via the calculation of the sink code. Following that, the K-means clustering technique may be used to complete the clustering process. The whole network model, which includes 500 sensor nodes, is used to generate the five clusters. Each cluster in the network architecture consists of a cluster leader and a number of cluster nodes. Figure 4 shows a five-cluster configuration; these clusters may be seen using a rainbow of hues, from pink to sky blue to blue to red to green. Each cluster is led by a "cluster head" that relays messages solely to the "sink node," while the "cluster members" are the other nodes that follow the cluster head's orders. The sink node acts as a leader formation in the event monitoring system, with five distinct nodes (cluster heads) following its lead. Figure 5 depicted communication that was limited to a specific geographical area. A particular area is picked to serve as the channel of communication. In this case, the GD method chose the sink node, and the K-means clustering algorithm was used to generate clusters and choose the cluster heads.

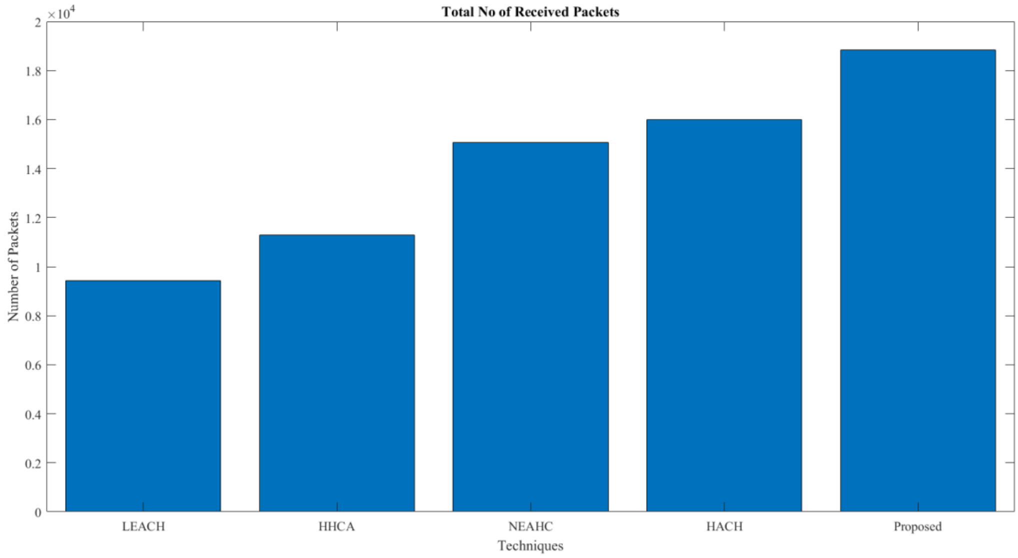

Figure 2: Analysis of received packets

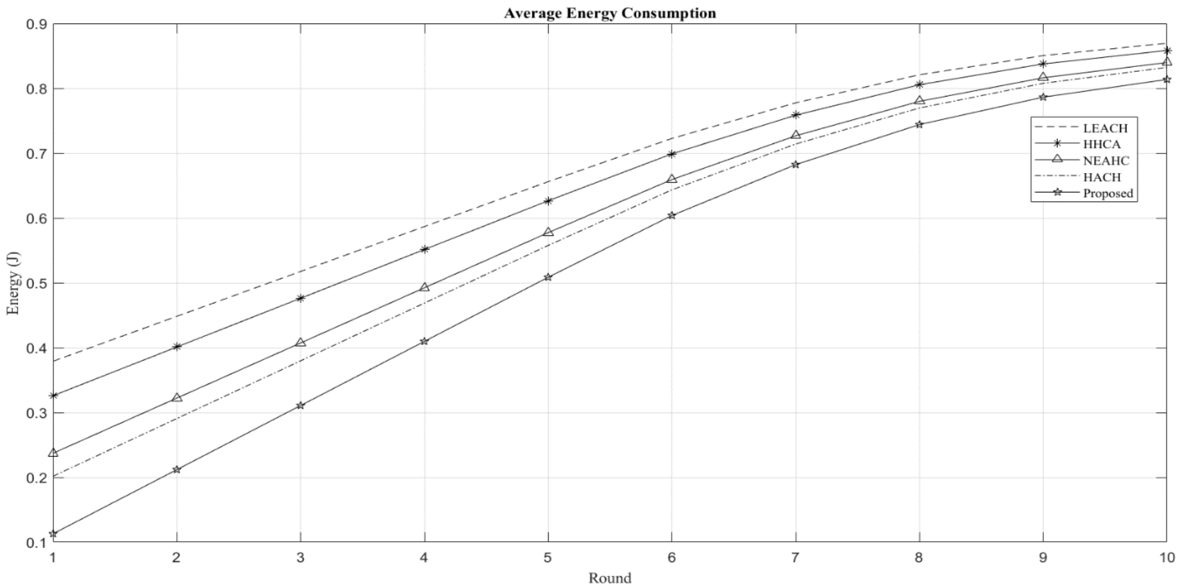

Figure 3: Analysis of energy consumption

In Figure 2, we see the system's received packets. Existing approaches such as LEACH, HHCA, NEAHC, and HACH are compared to the number of received packets. The suggested approach is used to successfully receive all 18000 data packets in the no-loss scenario. Existing techniques such as LEACH, HHCA, NEAHC, and HACH all use different amounts of packets per second to receive data: 8000, 11,000, 15,250. Using the suggested technique, the receiver side data packets were maximized more so than with previous methods. The results show that the suggested strategy outperforms the state-of-the-art approaches. Figure 3 depicts the total power usage of 500 nodes in a WSN across 10 rounds. Energy usage is evaluated in relation to standard practices such as LEACH, HHCA, NEAHC, and HACH. The energy used in the third round may be included into the analysis. It has been shown that the suggested method may significantly reduce energy usage, down to the 0.3J level. Energy is kept constant at 0.55J for LEACH, 0.48J for HHCA, 0.4J for NEAHC, and 0.38J for HACH. The suggested technique has reduced energy consumption in the sensor nodes at the third round level compared to the current methods. Finally, an algorithm is presented to lessen the load on the WSN's power supply, which is seen as the superior tactic. The suggested method's performance study demonstrates the efficacy of fault node recovery and energy efficient clustering using GD, K-means clustering, and the GA algorithm.

5. CONCLUSION

In this particular piece of research, the GD was put to use in order to identify the sink node and the failure node in the network. Following that, K-means clustering was used to organise the networks, with the selection of cluster heads taking place. The node's energy level was used to determine which group within the cluster would serve as the cluster head. In the end, a genetic algorithm was employed to determine the ideal route selection and to replace the node that had failed in the WSN. In order to demonstrate the usefulness of the suggested approach, it was contrasted with the LEACH, HHCA, NEAHC, and HACH procedures that are currently in use. The results of simulations using current approaches show that our newly suggested method is superior in terms of fault node recovery and energy efficient clustering. The approach that was presented was evaluated using a variety of performance indicators, including energy consumption, the number of received packets, the number of fault nodes, the number of living nodes, and residual energy. When using the method that was suggested, the amount of energy that was used was found to be 0.3J. In a similar manner, the energy level of the LEACH, HHCA, NEAHC, and HACH is maintained at 0.55J, 0.48J, 0.4J, and 0.38J accordingly. In the future, the suggested approach should also be developed to operate in the heterogeneity levels of the architecture of wireless sensor networks.

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