



Potential Energy Efficient Data Fusion Model for Wireless Sensor Networks

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Abstract

Wireless sensor networks have made a significant contribution to wireless sensor communication system based on resource constraints and limited computational sensors. Over the last decade, several focused research efforts have been made to investigate and provide solutions to problems relating to the energy efficiency data fusion aggregation in Wireless sensor networks. However, the problem of designing routes that are energy efficient has not been resolved. It is rather a tough effort to guarantee that the lifespan of a sensor is prolonged for a longer period because of the restricted computational capabilities of sensors, which are often coupled with energy constraints. The findings of this work present an enhanced energy-efficient technique for communication in sensor networks which consists of three distinct innovative frameworks. The suggested framework known as Data Fusion with Potential Energy Efficiency (DFWPEE) is responsible for the optimization of energy. The proposed work reduces energy consumption by using probabilistic methods and clustering. During the data fusion process, the Multiple Zone Data Fusion (MZDF) architecture uses a globular topology that helps with load balancing. The strategy presents an innovative routing approach that is used to aid in the performance of energy efficient routing in large-scale wireless sensor networks. By introducing the idea of routing agents, the framework for the Tree-Based Fusion Technique (TBFT), as suggested, comes up with an innovative method for dynamic reconfiguration. The plan enables the system to determine which sensor has a higher rate of energy dissipation and then immediately transfers the job of data fusion to a node that is more energy efficient. This threshold-based technique enables a sensor to perform both the role of a cluster head and the function of a member node. The node behaves as a cluster head until it achieves its threshold remnant energy and functions as a member node after it passes the threshold residual energy. Both of these roles may be played simultaneously. The mathematical modeling was done using the conventional radio energy model which improved the dependability of attained results. The proposed system delivers enhanced energy efficient communication performance when measured against existing implemented standards for energy efficient schemes. The enhanced technique uses nearly half as much energy as LEACH while focusing on reducing the overall time taken for the process to complete leading to enhanced performance.

Keywords: Tree-Based Fusion Technique; Energy Efficient Data Fusion; Data Aggregation; Wireless Sensor Network

1. Introduction

In recent times, one of the most growing fields in computer networks' research is the wireless sensor networks (WSNs) which integrates the abilities of sensing, processing and communicating data [1]. WSNs are used to improve the efficiency of a wide range of real time applications like industrial automation, consumer electronics, business, health care, automotive and avionics. These all industries use WSNs by incorporating them into their real time embedded systems. When compared

to wired networks, wireless sensor networks (WSN) [2] offer several benefits, including the absence of wires and cabling, a lower cost of installation, a smaller size, and the ability to be reused, as well as many other benefits, to meet the emerging requirements of a wide range of applications.

WSNs have the potential to be used in a broad range of contexts. However, several challenges need to be overcome like consumption of energy, computing power, lifespan, the bandwidth of wireless networks, memory are some of the problems that need to be addressed. To address the issues that have been recognized and to extend the useful life of the wireless sensor network, several strategies relating to routing [3], power management, and data aggregation have been presented and developed. These strategies were developed to solve the problems that have been identified in WSNs. WSNs are getting better at using energy and power owing to better at routing and combining data. This makes it easier to use WSNs for applications that are still being developed.

A wireless sensor network, also called a WSN, is a group of sensors that are connected on an ad hoc basis. Each sensor is an electrical device that comes cheap and small and works with other sensors to collect information.

Devices known as battery-operated wireless sensor nodes are in a position to exchange data with one another and may do so independently in any pre-existing infrastructure. "Sensor nodes" is the name given to these particular nodes in the network. The architecture of a sensor node is made up of three fundamental components. These components include a sensing subsystem, a processing subsystem, and a wireless communication unit. The sensing subsystem is responsible for sensing various environmental attributes concerning the process of sampling signals. The processing subsystem is responsible for aggregating data, processing it, and storing it. The wireless communication unit is responsible for transmitting and receiving signals. The sensing procedure is carried out in its whole by these subsystems, each of which is accountable for a distinct part of it. Every sensor node has a power source in the form of a battery, and this power source can only provide a certain amount of power.

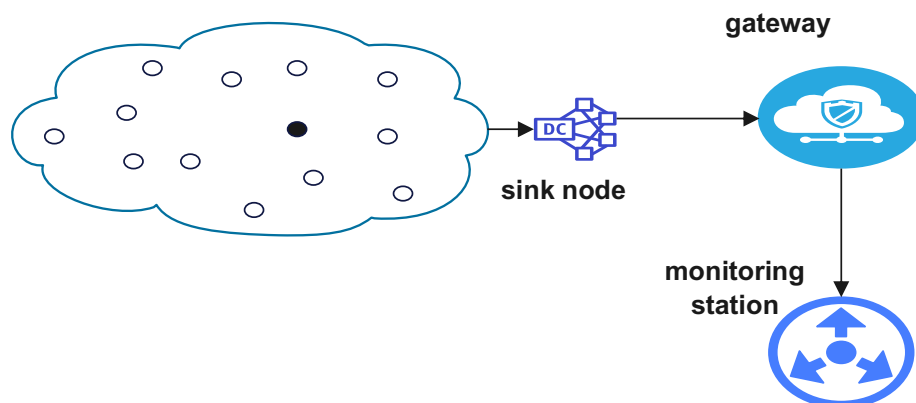


Figure 1: A Typical Architecture of WSNs

A typical architecture of a WSN is shown in Figure 1. This architecture is made up of several distinct sets of sensor nodes that are located in various parts of the world. With the support of a single operating system, each sensor node making up the architecture carries out several different Application programming interfaces (APIs) [5]. The recent research trends emphasize on the fact that all sensor nodes belonging to a WSN are located in a particular deployment region and when grouped together form a cluster. This forms the central tenet of current research trends. It is impossible to have a fully functional cluster without a cluster head, which is an accumulation of resources that are both more powerful and more efficient computationally.

It is the responsibility of each cluster head to manage and gather the aggregated data from the sensor nodes that are associated with its cluster. These sensor nodes follow a data collection procedure to sample the received signal. The analog sampled values are then transformed into digital numeric values for further calculations and pre-processing. The information is then collated by each cluster head and sent to a sink node for next process. An A sink node or an electronic device analyses the gathered data and transmits the processed data to a monitoring station through a gateway node. An analog-to-digital converter is a component that is built into the architecture of each sensor node. This component's primary function is to convert conditioned sensor analog data into digital values.

A sensor node is a device that is powered by electrical and electronic characteristics and is responsible for detecting some of the most important physical properties, like smoke, moisture, heat, pressure, motion, temperature, and humidity, amongst other things [6]. The sensor nodes are spread out across the region that needs to be surveyed in order to collect the required data. The nodes are often deployed in either a random distribution (where the location of the network is uncertain) or a uniform distribution in the majority of instances. [7].

MZDF (Multiple-Zone Data Fusion Technique): This stage is a subsequential expansion of the prior stage called PEEDF stage. An analytic modelling approach was used in the production of MZDF [8]. The Multiple-Zone data fusion strategy proves to be easy to implement and highly; efficient and hence proposed as a result of this work (MZDF). The concept of zones allows MZDF to further increase its power of data fusion, which is one of its primary functions. Zones are used in order to enclose nodes inside the network that have either taken part in the data fusion process or have not taken part in it. This is something that MZDF is able to do since it has the capacity to significantly increase its data fusion capabilities. It has been explained how a novel approach to topological design may be used to enhance the effectiveness of data fusion, with a specific concentration on the demands placed on the system by large-scale applications' need for high performance. The 'threshold-based' energy model is utilised throughout this work with the intention of simplifying the process of designing for data transmission. This was one of the primary motivations for using this model.

The general strategy that was employed in this study makes an effort to enhance data fusion strategies, which is important when it comes to the use of large-scale sensory data collected from many availability zones of sensing. This was the major purpose that this endeavour was intended to accomplish. When compared with LEACH in terms of performance metrics like network longevity, the findings of the simulation reveal that the proposed fusion mechanism performs much better than LEACH.

TBFT stands for Tree-Based Fusion Technique. During this final stage of the technique's implementation, the key objective is to achieve optimization in data fusion in WSNs. The TBFT technique enhances the effectiveness of data fusion by supplementing it with a basic and novel tree-based mechanism that is separate from other methods that currently exist. An analytical approach has been adopted in this stage of the proposed work. Adhering to the strategy, a tree-based data fusion method is implemented using an additional module known as core fusion node. This additional module guarantees that the fusion node combines data in an energy-conscious way to eliminate redundant information before sending it on to the base station over several hops. The proposed network architecture incorporates a novel kind of node referred to as a Hub Fusion Node (HFN). The HFNs are required given that the suggested system has developed tree-like topologies.

2. Related Work

The theoretical computation developed in [9] is capable of effectively modifying the system topology within the cluster to reduce the amount of energy used for communication. This was accomplished by reducing the number of nodes that are connected to each other. This, in turn, makes the system last longer and gives acceptable performance levels for sending information.

An exploratory study has indicated the predicted lifespan of a sensor node powered by a battery may be greatly extended if the recommended calculation is applied. The node in question is the one that is powered by a battery.

The study also reveals that adhering to OCMRA guidelines may increase the lifetime of systems. This is attained by lowering the amount of activity carried out by the component of the sensor stage whose operation necessitates the use of the highest amount of energy. The study, [10] offered a Fitness-based Routing Protocol (FRP) as a technique for supporting more effective information transfer while using less power. This was accomplished via the use of a network protocol. It is feasible to reduce the amount of energy used by sensor nodes if one chooses the nodes having the least jump tally and spacing. In lieu of more time-consuming techniques, the calculation of ancestry is utilised in order to zero in on the node that, from a design standpoint, is the most suited for the network as a whole. A concept that was developed by [11] is one in which a node that has acquired the greatest amount of information is given the first need to go to the channel, and then sends the

information that it has obtained to the sink by eager direction. This is an example of a scenario in which a node would be given the first need to go to the channel. Information is transmitted using a variety of methods in order to reduce power consumption while maintaining a high packet delivery ratio. As a consequence of this, the process of identifying the precise instant at which the break occurs leads to a considerable increase in the quantity of information that can be sent.

[12] used a protocol known as Ad Hoc on Demand Multipath Routing in order to determine the many different pathways that could be used to transmit the information from the source node to the destination node. The two nodes of a network were linked together to successfully complete this task. The suggested job effectively carried out the productive data transmission in an energy-efficient manner while the sink node (base station) was in a static condition. This was finally completed after ensuring that all of the other neighbour nodes were in the ready state.[13] studied how a base station may help with progressive bunch-based routing by employing LEACH, which might also replace information collection during the setup process. The revolution premise includes a component known as a "gathering of cluster heads. This part is in charge of getting information from neighbouring nodes and sending it to a separation base station.

[14] proposed a typical further focused routing protocol that they referred to as WRP. The longevity of the system is going to be increased with the help of this approach. In WRP, the sink node is often thought of as having more capabilities than the other nodes and is largely accountable for accumulating the projected wake-up time of each node. Even though some of the sensor nodes are a few bounces away from the sink node, this tells the sink centre to check the wake-up times of all of the sensor nodes.

When a large number of connections are severed, the analysed data is used to find an alternate path that does not result in flooding. [15] has presented a detailed explanation of an efficient conventional protocol for conveying energy information to remote sensor devices. This protocol is known as the Energy Aware Geographic Routing Protocol (EAGRP). The lifetime of the scheme is going to be extended with the help of this protocol. Users have access to both energy and location data at each node that is used in the EAGRP to route packets from their sources to their destinations. These nodes are used to route packets in the EAGRP. This results in decreasing the lifespan of the sensor as well as the system. However, it is still feasible to attain a higher packet delivery rate with a slight reduction in energy efficiency. This is because of the fact that an 18-foot-efficient and energy-conserving directing strategy for multi-bounce remote sensor systems is being proposed as the norm that should be followed. The guiding configuration of EAGRP takes into account two factors in its decision-making process – one being the regions and other, the different energy levels of the nodes. The measurements of the execution are broken down using a variable number of nodes, and each node is aware of the surface area and energy level of the nodes that surround it. The analysis shows that the proposed approach not only lessens time but also has improves packet delivery rate. Furthermore, optimum usage of available energy is also achieved.

The study was carried out by introducing a novel solution to the challenge of efficiently sending data packets over dispersed sensor networks in an environment friendly way. The system is sensitive enough and tuned which results in accommodating sensor systems and different types of sensor nodes which are able to detect energy in their own way. [16] proposed a trust-aware directing convention that is area-based and safeguards the WSN against routing assaults while simultaneously providing support for large-scale WSN organisations. It has been shown that the proposed configuration is capable of correctly discriminating between friendly and hostile nodes while simultaneously keeping a strategic distance from the latter. Additionally, the suggested arrangement has been realised in sensor nodes that are considered to be the finest in their class in order to serve as a legitimate proving ground. This work refers to the cost of figuring out measuring usage and the lessons learned while setting, implementing and analysing the secured results.

They have presented a novel Power-Aware Two-Hop (PATH) based continuous routing standard. A track makes it possible to enhance the ongoing execution of the method by reducing the number of direct alternatives for dropping parcels, as is done in this convention. The strategy is based on the idea of making use of two jump neighbors' data and a force control instrument. This is in light of the concept of making use of two jump neighbours. While the former is employed to make operations more energy efficient, the latter is transmitted in order to increase joint quality while simultaneously lowering the number of data packets that are delayed. Both of these goals are concurrently pursued. A further computation that is an improved version of the LEACH standard is called the LEACHTLCH calculation. This calculation was developed by [18]. It is predicted that the results of

this computation will result in a reduction in the whole system's energy consumption as well as an extension of the system's lifespan. The reproduction step is used to make a copy of the new calculation in Matlab. The results of this copy show that the system uses less energy and lasts longer than anything the LEACH Protocol has to offer.

It is safe to assume that the great bulk of the research that has been done in the past has been on modelling data aggregation rather than data fusion approaches. This is because modelling data aggregation is easier to do. As a direct result, these kinds of approaches are only used with methods that are based on fusion.

Utilization of information that has been pre-defined when making judgments, a sensor network that serves applications that are both time-critical and mission-critical uses data that has been planned as well as data that is collected during runtime. Existing research, on the other hand, only makes use of static knowledge that has been specified in advance when marketing.

It has a weaker connection to energy efficiency. Despite the fact that a large number of studies have been conducted in the direction of energy efficiencies in sensor networks, unfortunately, those studies have not been conducted taking into account data fusion technology. Even though there have been a lot of studies done on how to make sensor networks use less energy, this is still the case.

There has been a decreased focus on the computational complexity of problems in recent times. The vast majority of systems in the market today make superior claims about the performance of their communication capabilities; however, they do so at the expense of increasing computing complexity. Approaches that make use of ANN, GA, or SVM have a larger use of iterations with bigger epoch values, which makes it hard for these strategies to be carried out on a sensor node that has constrained resources.

Therefore, the topics that were covered up to this point constitute the primary research gaps that are now present in connection to the enhancement of the data fusion operation for the purpose of greater energy efficiency in wireless sensor networks.

3. Proposed Work

The proposed model's main purpose is to carry out an optimization of the many sources of energy that are currently accessible. The study that was provided includes a presentation of an optimization framework that goes by the name Potential Energy Efficient Data Fusion (DFWPEE). This framework ensures that the cluster leader in wireless sensor networks may be selected in the most efficient way possible, hence maximising the network's overall performance. In order to conduct calculations about the likelihood of picking the cluster head based on the findings of the simulation study, the logic of probability theory is applied inside the system. These computations are based on the results of the simulation. The method that has been suggested is implemented, in its most basic form, on each of the sensor nodes that are scattered throughout the whole of the simulation space. It starts its operation as soon as the 48-foot sensor acquires the unique data for a specific event and continues its operation until the data is communicated to the base station. It begins its operation as soon as the 48-foot sensor captures the distinctive data for a particular occurrence.

$$P_{Dx} = L \cdot (P_{elec} + P_{fx}xd^2); \text{ If } d < d_o \quad (1)$$

$$P_{tx} = L \cdot (P_{elec} + P_{mp}Xd^4).; \text{ Otherwise} \quad (2)$$

When designing the infrastructure of the proposed system, it was essential to take into consideration the many types of sensor nodes that are analogous to one another. Other considerations, such as the distance between the sensor nodes and the cluster head, as well as the amount of initial energy that was assigned to each sensor to begin with, were taken into account during the study that was carried out. It is expected that the location of the base station is positioned at a large distance from the cluster in order to get information on the stability and endurance of clusters throughout the course of their lifespan. The network model that is developed with an emphasis on energy efficiency serves as the motivation for the early phases of the system's design process, which may be thought of as its "genesis".

$$d_o = \sqrt{\frac{P_{fo}}{P_{up}}} \quad (3)$$

The empirical section of the study investigates testing the model with L bits of information that need to be processed while using a certain amount of energy and while being separated by d distance. The investigation also takes into account a quantity referred to as Pelec. This quantity represents the quantity of energy required to process one unit bit of data from the perspective of the hardware circuitry for both the receiver and the transmitter. Pelec is taken into consideration in the investigation. The system takes into account an additional variable of distance referred to as d_o (as shown in Equation 3). d_o is computed by making use of the square root of P_{fo} and P_{mp} in order to reflect the quantity of energy that is frittered away unnecessarily as a result of the inefficient transmission method. As a consequence of this, the quantity of transmittance energy required to transport L bits of a data packet from one sensor node to another may be represented as

$$P_{Dx} = L \cdot P_{elec} \quad (4)$$

A more in-depth analysis of Equation (4) indicates that the equation is correct if and only if the transmissions distance d has complete control on the transmittance power P_{tx}. This conclusion was drawn after analysing the equation in more detail. When compared to the second equation in (5), which uses the fourth power of the transmission distance, the transmittance power dissipation will be reduced if the transmission distance is squared rather than using the fourth power. This will occur because the squared transmission distance will be larger than the transmission distance. As a consequence of this, it is abundantly evident that an exploitative strategy is being used in this scenario. In particular, the system should adhere to the empirical equation that incorporates squared distance in order to maintain a lower level of transmittance power dissipation. This is necessary in order for the system to function properly. An experimental expression of the amount of needless energy that is consumed to receive L data packets in bits is a better portrayal of the amount of energy that is squandered.

$$P_{CL} = \left(\frac{n}{k} - 1\right) \cdot L \cdot P_{dik} + \frac{n}{k} \cdot L \cdot P_{Du} + LE_{stax} + Ls_{fi} \cdot d_{gs}^2. \quad (5)$$

When it comes to the dependability of the equation's execution on any size of application in wireless sensor networks, it is quite easily justified without any further comparison. In order to further standardise the operation of the method, the proposed system takes into account the fact that the selection of the optimal cluster is carried out in the following manner if the distance measurement of the sensor nodes is greater than d_o. If this is the case, then the standardisation of the method's operation will be improved:

$$P_{SCL} = LP_{diec} + Ls_{fs}d_{\alpha}^2 \quad (6)$$

The proposed system, in contrast to pre-existing optimization methods such as recursive optimization, provides steps that are both straightforward and iteratively less complex in order to compute the optimal number of sensor nodes that should be participating in the process of data fusion. These steps are designed to determine the optimal number of sensor nodes that should be participating in the process of data fusion. This is done so that the suggested system may be distinguished from other optimization approaches that are already in existence. Equation highlights an empirical approach for calculating the total number of elite sensor nodes in a wireless sensor network that are capable of carrying out data fusion. This method may be used to determine the total number of elite sensor nodes in a network (6). The very low power consumption of wireless sensor networks is taken into consideration by this approach. In contrast to the traditional method, in which the selection of the cluster head is made solely on the basis of the residual energy and the iterative process, the recently proposed system takes into account a wide variety of characteristics before arriving at an estimate of the power that is required. This is in contrast to the traditional method, in which the selection of the cluster head is made solely on the basis of the residual energy and the iterative process. The optimization principle is used, and the improved probability of a normal node being picked as the likely cluster leader is empirically found as, n k p best. This formula represents the improved probability of a normal node being selected as the likely cluster leader. Because of this, the normal node has an increased probability of being chosen.

$$d_{CL}^2 = \int_0^{x_1} \int_0^x ((x^2 + y^2) \cdot \rho(x, y)) dx dy = \frac{M^2}{2\pi k} \quad (7)$$

The equation in emphasises the likelihood that a typical sensor will be able to perform data fusion with the highest level of certainty, and this potential is brought out by the fact that: (7). Taking this into consideration, it seems that the proposed system lends a hand in the extraction of information essential to the choice of the sensor that is the most appropriate when the test is being carried out. This process gets rid of a sizeable number of iterative processes, which in turn reduces the amount of time needed to respond to an event and shifts the burden for the task from an older cluster head to a more current one. Because an incorrect selection of the cluster leader will not perform the dissemination of the data efficiently from the clusters to the base station, resulting in the drainage of energy and the consumption of unwanted resources as well, the primary objective of the proposed study of DFWPEE is to select an effective cluster leader. This is because an incorrect selection of the cluster leader will not perform the dissemination of the data. This is as a result of the fact that the research that was carried out in emphasising that the overall quantity of depletion of energy throughout the whole sensor network in each and every iteration grows has come to the conclusion that this is the case.

$$P_t = L \cdot (2 \cdot n \cdot P_{di\varepsilon} + n \cdot P_{Dd} + (k \cdot d_{ks}^2 + ndd_{CL}^2)) \quad (8)$$

$$d_{As}^2 = \int_A (x^2 + y^2) \cdot \frac{1}{A} = 0.765 \cdot \frac{M}{2} \quad (9)$$

It is a common practise to disseminate information on the amount of energy that is still available in the communicating sensor nodes when designing activities that include updating data. This is done with the goal of extending the period of time for which the network is able to sustain the sensor nodes. The process is carried out in the same fashion even for the later phase of picking the leader of the cluster.

It is possible to proceed with the procedure provided that the collected energy of the sensor nodes is not completely depleted, but doing so is contingent upon the fulfilment of this requirement. The proposed method does not make any provision for the selection of a potential cluster leader who has already fulfilled the responsibilities of a cluster leader in the past. This is done to make sure that the process for picking the cluster head is as straightforward and devoid of ambiguity as is humanly practicable. In the following section, we will discuss the research method that has been used in this study in order to accomplish the objectives that have been outlined for this investigation.

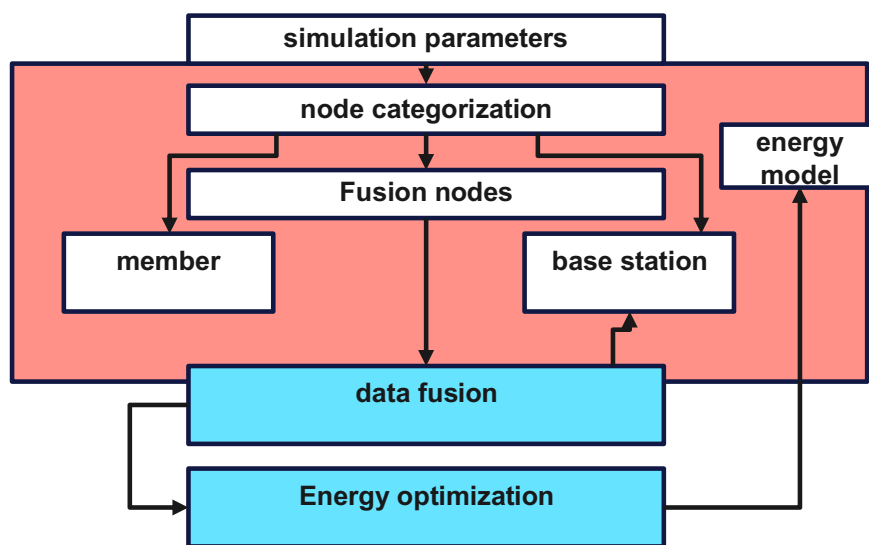


Figure 2: Proposed Architecture

In the DFWPEE study that is being proposed, the research method includes both analytical and empirical approach. Utilizing probabilistic reasoning was the key to achieving the study method's primary objective, which was to design a system that would enable the sensor nodes to participate in the selection of the cluster leader in the most efficient and effective manner. This was accomplished with the help of the study technique. A schematic illustration of the DFWPEE design that has been suggested may be seen in the area of Figure 2 that has been highlighted. The procedure starts with the building of the network model, which is followed by the transmission of the aggregated data from the sensors to the base station by means of the cluster leader. The last step of the process is the analysis of the data. A hierarchical clustering approach is adopted because of the energy efficiency attributes it has in respect to the residual power of the sensor nodes. The hierarchical clustering method was chosen because of these features. The approach that has been recommended will make use of a lower number for the initial energy, and it will be given a chance of picking the cluster leader for each growth round that is equal to 5% of the total probability. These modifications are being implemented into the system in order to bring it into closer alignment with the current state of affairs.

The development of a probabilistic reasoning scheme that can effectively choose the optimal cluster leader and controls the other nodes to become cluster leader in the consecutive rounds of simulation study is the most critical aspect of the design principle. This is because the scheme must be able to effectively choose the optimal cluster leader. It is necessary to devise this plan in order to bring it into conformity with the needs of the design concept. The candidate nodes each have an enough amount of energy, which enables them to be self-eligible for the subsequent round of the competition to become the cluster leader that is being conducted by the simulation study. The method takes into consideration not just nodes that are contenders for the post of cluster leader, but also nodes that are not candidates. These are nodes that have a much lower overall amount of energy and a reduced possibility of taking on that position in the network. On the other hand, during the future phase of the simulation's progression, there is a chance that non-candidate nodes will be elevated to the position of candidate nodes. This is a possibility. Once again, the technique for picking is based mostly on the level of leftover energy that has been accumulated.

4. Experimental Results and Analysis

While the recommended research study is being carried out on Windows 32-bit operating system with a dual-core CPU running at 1.84 GHz, the Integrated Development Environment being used is MATLAB. The proposed work has been evaluated and verified using a simulation area measuring upto 300 millimetres on each side. Here are a few distinct scenarios that are taken into account, each of which has between 60 and 100 nodes and a random distribution. The initialization procedure consists of 150 rounds, and the beginning energy of fusion nodes is set at 0.1 Joules. There are also 150 rounds to finish the process. The LEACH method, which is used by a large number of people, is compared to the strategy that was only recently recommended. The following is a list of the parameters that were considered while running the network simulation:

This work's sole purpose is to ensure that the implementation of the schema maximises the non-redundancy of the data fusion while simultaneously minimising any unwelcome difficulties in terms of power consumption. The components of the rule have been developed such that the heterogeneous ranking type is an improved version of the deterministic schema which is used in the homogeneous ranking type.

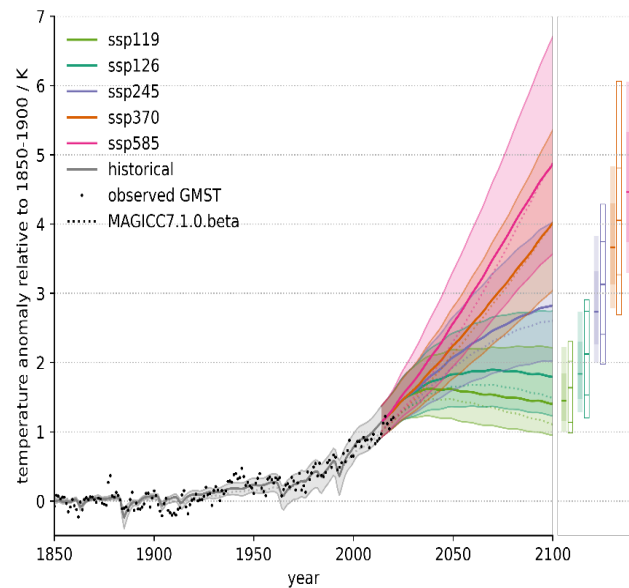


Figure 3: Simulation of the DFWPEE schematic

Figure 3 depicts the results of a simulation of the DFWPEE system that was proposed. Within the context of this simulation, it is possible to demonstrate the local optimality of the fuser node ranking information. As part of the heterogeneous ranking aspect, in addition to power, information concerning scores for tolerance and data dependability will be deployed (0.1 J). Adjusting the sizes of the neighbour nodes is how the experiment is carried out. It is clearly represented that the number of neighbouring nodes which are closer to each other have a direct link to the practicability of the data dependability on the data fusion node.

Figure 4 presents the information about the data fusion reliability score as well as the tolerance of the Heterogeneous Ranking Factor. This material relates to several aspects of energy. It is observed from the figure that the feasibility of the fusion node increases as the number of nodes increases, along with their individual energy levels. This allows for a greater chance of obtaining a data packet that is uniquely indexed and has been presented in the figure. Another significant discovery is that the Heterogeneous Ranking Factor itself selects the candidate fusion node that has the most feasibility by taking into consideration, energy and the total number of neighbourhood density. This is an important finding since it demonstrates how the HRF works. As a direct consequence of this, the DFWPEE scheme's fruitful execution inside the WSN network is a foregone conclusion.

Figure 4 illustrates the Homogenous Ranking Factor tolerance and the information on the data reliability score. In this case, it is easy to observe that a rise in the value of the Centroidal positioning factor (CPF) with regard to the distance, position, and total involvement of fusion nodes enhances the feasibility of uniquely indexing the received data packets. This is depicted in below graphs. Figure 4 also illustrates how the DFWPEE variable has affected the CPF (Homogenous Ranking Factor).

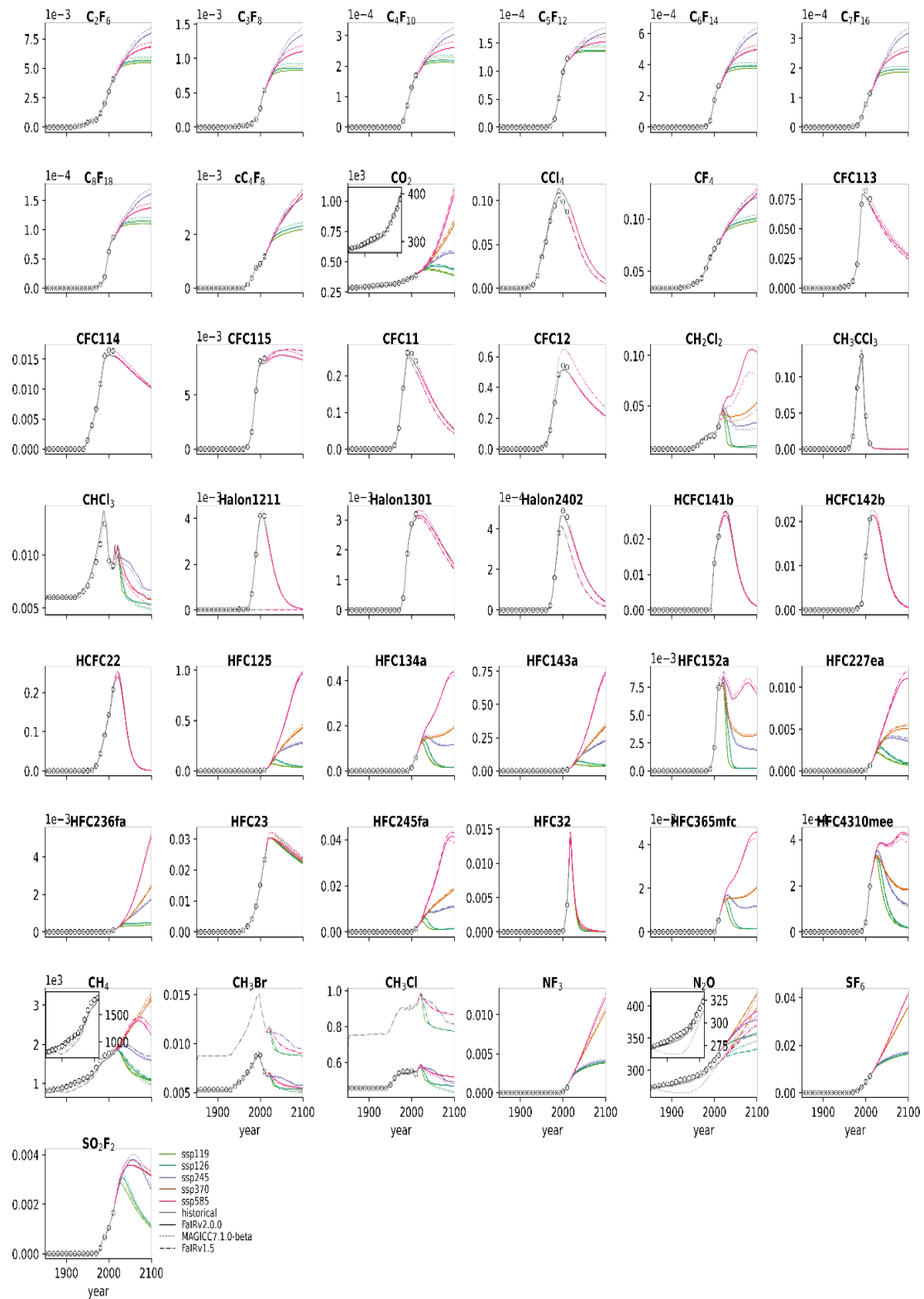


Figure 4: the DFWPEE effect on the density of the neighbourhood (using the heterogeneous ranking factor).

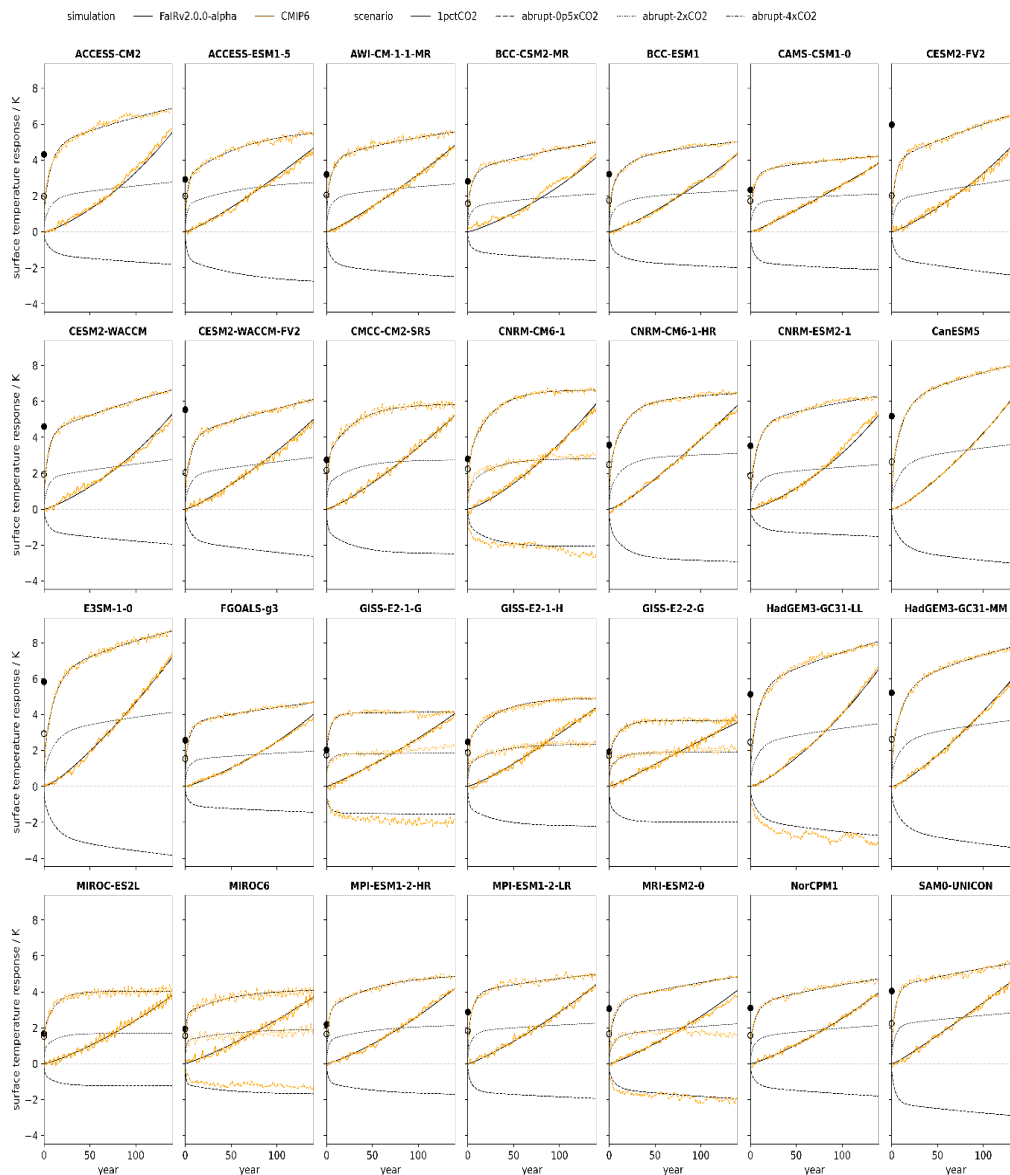


Figure 5: Effect of DFWPEE on Energy

Figure 5 is an illustration of the Homogenous Ranking Factor tolerance as well as information about the data dependability score in relation to the distance that separates the fusion node from the sink. Figure 4.11 demonstrates that despite a rise in the value of the Immediacy Factor (IF), the Homogenous Ranking Factor tolerance remains best for curves with CPF=3000 and TxD=30m when compared to curves with CPF=6000 and TxD=60m. This is because curves with CPF=3000 and TxD=30m have a lower value of the Immediacy Factor (IF) than curves with CPF=6000 and T. This remains the case despite the fact that the IF values are becoming higher. The occurrence of this event suggests that DFWPEE is using a more efficient technique for optimization.

When the number of fusion nodes is increased from 30 to 40 and then to 50, it is feasible to see that the heterogeneous ranking factor reaches its maximum value simultaneously with the expansion in the total number of nodes. This is the case both times and is observed in previous statement. Therefore, it is reasonable to argue that the chance of unique incoming data being indexed increases in proportion to the quantity of the heterogeneous ranking component that is present. This may be expressed as "the likelihood of unique incoming data being indexed."

Figure 6 illustrates the influence of DFWPEE on CPF and TxD (Homogenous Ranking Factor).

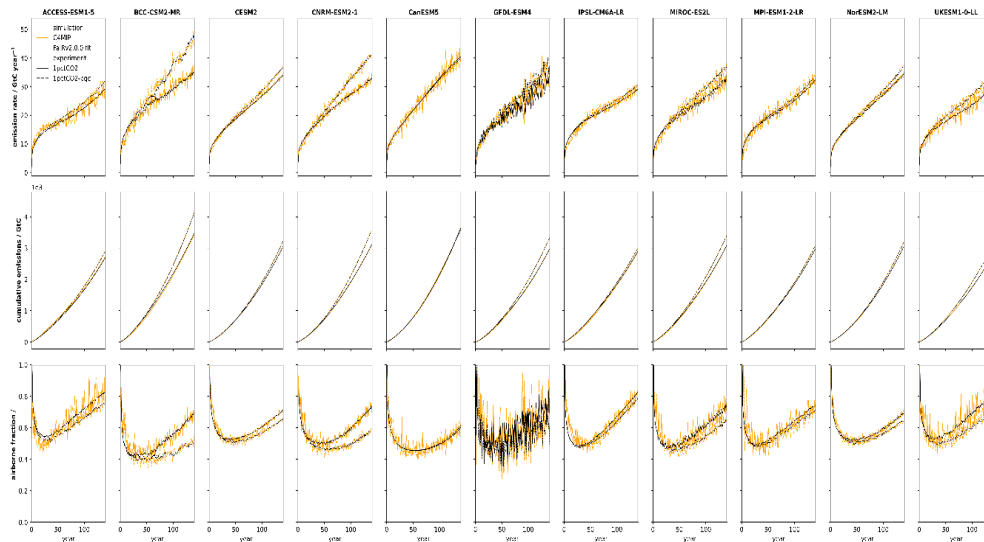


Figure 6: the effect of DFWPEE on CPF and IF (Homogenous Ranking Factor)

The information on the Homogenous Ranking Factor tolerance score in relation to the distance from the sink is highlighted once again and could be observed in Figure 7. As a result, it is clear that the system that has been proposed has highly optimised the Homogenous Ranking Factor of the non-deterministic Logic implementation. This was done in order to keep the maximum amount of power that could be retained, as well as to make a better and more effective choice of robust fusion node while using an extremely small amount of network overhead. This was done in order to reduce the amount of labour needed to keep the network operational to the greatest extent possible. As a consequence of this, the system that has been described is highly effective in terms of processing, and it is even capable of being used in an environment that operates in real time.

The widely known LEACH protocol is carried out alongside the DFWPEE protocol and a comparative analysis of both protocols has been done. This comparison is dependent on the simulation parameters that were previously taken into account. Figure 7 presents a comparison of the number of live nodes discovered by using the proposed technique and the LEACH protocol. These results clearly indicate the performance superiority of proposed technique w.r.t the LEACH protocol. During the first several hundred iterations of the LEACH protocol, the total number of live nodes start to gradually decrease, but this trend eventually comes to a stop. The DFWPEE protocol that has been developed, on the other hand, includes a steady and smooth decrease in the number of nodes that are still active. According to the results, DFWPEE has the ability to ensure that the total lifetime of the wireless sensor network is maximised to the greatest extent possible.

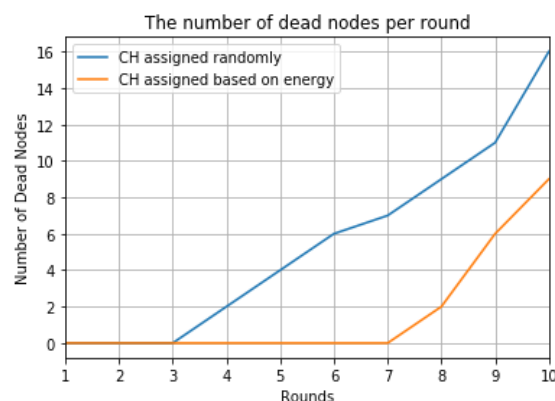


Figure 7: A comparison with LEACH (Alive nodes Vs. Iteration)

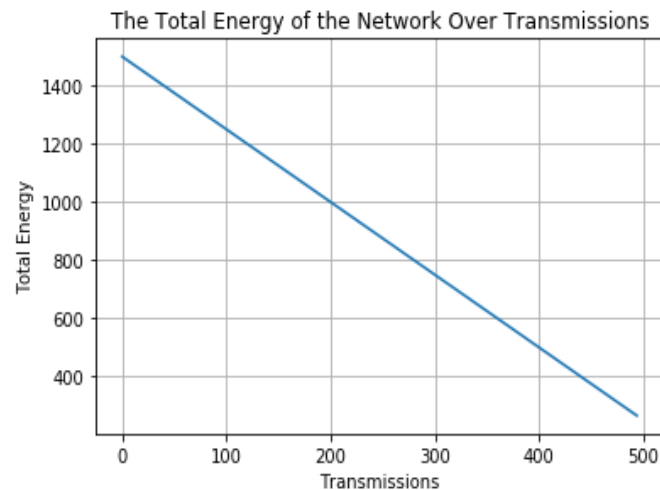


Figure 8: The nodes' remaining potential energy.

One of the most significant differences between the LEACH and DFWPEE implementation methodologies is shown in Figure 8. One can see that there is a sharp decline in the slope of the curve that is used to represent the residual energy for LEACH in and around a number of iterations that is lower than 300. On the other hand, the suggested ENLPL has a decline that is slow, linear, and smooth, and terminates somewhere in the vicinity of 700 iteration stages. Consequently, the use of PEEDF may result in improved energy saving. The examined findings make it precisely clear that when using the LEACH protocol, sensor motes run out of power at a very early stage, whereas the proposed protocol, is designed to provide maximum amount of power.

Therefore, one of the most important aspects of comparative analysis needs to be collecting data of the power variance parameter. It has been noticed that the suggested protocol has a mean (First Node Death) FND value of around 656 out of 700 observation rounds, while the LEACH protocol has only 378 out of 700 observation rounds. The power variance vs the total number of 700 observation cycles is shown in Figure 9.

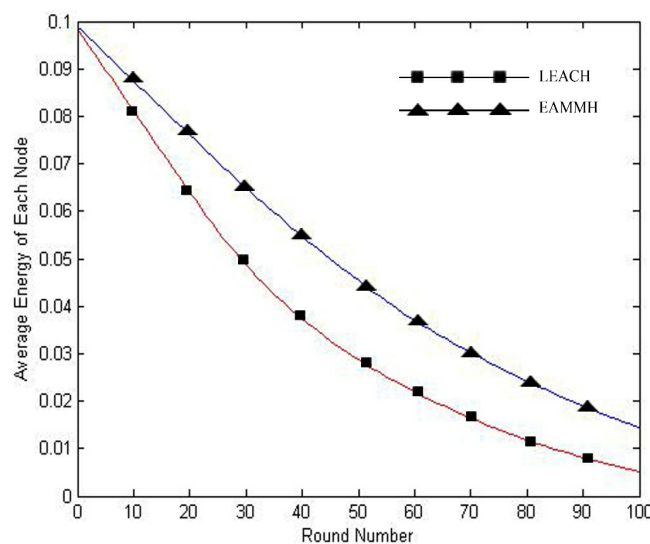


Figure 9: illustrates the power variance in relation to the number of iterations.

It is essential to take into account the parameter of First Node Death (FND) in order to visualise and compare the efficacy of the algorithm for maximising the cumulative network lifetime when conducting an analysis of the power efficiency of the proposed system using the LEACH protocol. This will help ensure that the maximum amount of cumulative network lifetime is achieved.

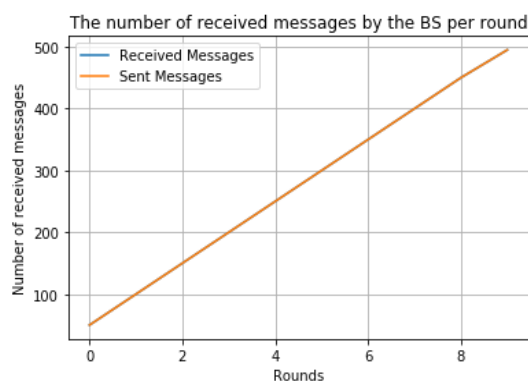


Figure 10: displays the data for the First Node Death event for both the proposed and LEACH methods.

It is clear from looking at Figure 10 that the suggested method does, in fact, aid the sensor nodes in making use of the electricity in a consistent manner.

It is also possible to say that the power that is allocated to the sensor nodes in the conventional LEACH protocol often deflects with select sensor nodes that have extremely high-power allocation, while other sensor nodes are drained of power until they have 0 joules remaining. However, it is clear that the problems with the LEACH protocol that were discussed before have been overcome by the proposed system. In the LEACH protocols, the nodes would run out of power in around 370 rounds, while in the proposed system, the power wouldn't run out for approximately 690 rounds.

5. Conclusion

When constructing a routing scheme for a wireless sensor network, one of the most significant factors that needs to be considered is energy consumption. It is conceivable to study the usage of the LEACH clustering approach in this setting; this technique chooses a leader for the cluster based on a probability framework. On the other hand, LEACH is simply based on a probability framework, which states that some clusters may be pretty close to one another and may be located on the edge of the WSN. This is because some clusters may be relatively close to one another. When these inefficient cluster leaders are used, however, it is impossible to enhance the energy efficiency to its greatest potential. The proposed method introduced the ENLPL protocol, which is designed to overcome the issues in LEACH by utilising Probabilistic Logic and selecting energy level, transmission distance, and density of nodes as the prime factors for election mechanism of cluster leader. In addition, the ENLPL protocol uses Probabilistic Logic to select energy level, transmission distance, and density of nodes as the prime factors for election mechanism of cluster leader. The challenges presented by LEACH inspired the development of this protocol. The technique that has been recommended puts a focus on the sensor nodes for the purpose of conducting extra estimations and allowing communication in order to get the data related to the node density and the transmission distance. Our attention has been drawn to the fact that the generation of clusters in the LEACH protocol is wholly dependent on universal knowledge. Without a doubt, in order to have access to this information, certain specific routing strategies are required in their entirety. The LEACH protocol may be seen as a semi-distributed protocol for wireless sensor networks when viewed in this perspective. Another significant issue with the LEACH protocol is its arbitrary method to selecting the leaders of the clusters. This approach does not ensure that the required number of cluster leaders will be selected, nor does it guarantee that the selected cluster leaders will be uniformly spaced. Neither of these things can be guaranteed.

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