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Improved Performance and Energy Efficient Low-Energy Adaptive Clustering Hierarchy (IPEE-LEACH)

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Abstract: *serious power limitations remain one of the greatest and most severe worries in wireless sensor networks (WSNs). Since the sensor network's performance is significantly determined by network lifetime, scholars remain observing for approaches to enhance the utilization of the node's power resource likewise maximizing the network lifespan. The environment at which the sensor nodes are positioned and the routing approaches are all affecting the usage of the battery. Several, quality of service (QoS) systems of measurement are delivered toward the measurement of the network efficiency and then aid in minimizing battery power utilization for routing stages. Various routing rules were suggested to deal with this problem. We presented in this paper to analyze the Improved Performance and Energy Efficient Low-Energy Adaptive Clustering Hierarchy (IPEE-LEACH) and measurement of the efficiency with others. The Moth Flame Optimisation (MFO) algorithm is applied to enhance the network efficiency. Power effectiveness, message delivery delay, and packet delivery ratio (PDR) remain the quality-of-service pointers that are supposed to measure effectiveness. IPEE-LEACH through MFO was discovered to accomplish well than opposing approaches in simulated results and proved that the offered method minimizes power intake and maximizes the lifespan of the network by outperforming LEACH by 26.5% and Eip-LEACH by 17.2%.*

Keywords: *Network Lifespan, Cluster Head, Wireless Sensor Network, Energy Efficient, LEACH, MFO.*

1.0 Introduction

Recently nowadays, information technology (IT) has made important progress in numerous areas, and things are transforming into digital systems and available on the internet or online. Wireless sensor networks (WSN) deliver a more efficient method for finding information from any place, even unreachable locations where human movement is nearly unbearable Daanoune, & Baghdad (2020). Many industries use different kinds of wireless sensor networks to improve their service quality or production in many areas (Mahboub, *et al*., 2019). Every sensor node (SN) takes as a minimum, one sensor node, which is liable for information gathering. The small SNs are categorized by their capability for self-adaptation, and self-configuration, and then they are energies from rechargeable or non-battery sources. wireless sensor networks are used in many varieties of applications, also they are self-organizing nodes and their cost is low, instruments that can sense many physical quantities comprising conservational physical variables, and the sensor nodes are tiny enough to be distributed within a large region. (Alnajdi & Bajaber, 2020) and (Balakrishna & Prasad, 2019).

Additionally, to reduce the battery life span, the huge power intake of different SN pieces decreases the general network's lifetime, meanwhile, the battery's power is the main reason for an SN extended lifetime probability (Nabeena & Najumnissa, 2019). Therefore, the main constraint inside the wireless sensor network is the use of electrical power, then it is essential to reserve power to prolong the lifespan of the network. Various study areas are categorized as challenges of optimization since they are worried about the discovery of helpful plan methods, like placement coverage difficulties, routing of data issues, and cluster head problems (Tsai, Hong, & Shiu, 2016). Many scholars have deliberate numerous routing procedures to be employed to limit the power intake of network nodes (Daanoune, Baghdad, & Block, 2019).

For every sensor node in the network, the battery remains the source of the cycle. It takes a huge amount of power to transmit or sense signals to other sensor nodes and takes a higher power to translate information and send the information gathered to a BS. A weak and dead battery replacement is always not possible in some conditions like surveillance or remote sensing. To solve these challenges, numerous researchers are trying to improve energy-efficient protocols for sensor networks in solving power effectiveness matters as previously stated above. Almost all the protocols that were developed and employed in wireless sensor networks must be capable of giving some amount of real-time backing since they are used to sense data, process, and transmit in reaction to happening that require an instant reply. If the protocol reacts rapidly and unfailingly to variations inside the network fields, then it is believed to have real-time provision and be capable of conveying standby information to the sink by using information gathered from each SN through the network setup. The period for transmission of data between the sensor node and base station must be short and cause a swift response.

The research aim is to minimize power intake and maximize the lifespan of wireless sensor networks by selecting cluster heads built on initial power remaining, optimizing the amount of sensor nodes inside the clusters, then identifying redundant sensor nodes so that they can send data to the base station.
The following objectives can be realized in this research:

- Development of a clustering-based energy-efficient technique for wireless sensor network.
- To develop a Sub-cluster LEACH algorithm, Moth-Flame optimization (MFO), and IPEE-LEACH,
- To assess the effectiveness of the offered technique.
- To enhance the existing algorithm according to the power effectiveness and stability of the network.
- To simulate the research using MATLAB network simulator.

2.0 Literature Review

The aim is to assess how numerous correlated routing techniques can increase the throughput and power effectiveness. Table 1. summarizes the discoveries of the many reviews related to LEACH clustering protocols.

Table 1. Assessment of some LEACH-related protocols.

Protocol	Cluster Formation	Energy Effectiveness	Connectivity	Extensions	Performance
Cell LEACH	Static	Yes	Two-hops	➢ Clusters comprise seven cells. ➢ Direct communication	➢ Reduces the power consumption.

				between the Cell leader and with cluster head.	➢ Prolongs the network lifespan
AEEC	Dynamic	Yes	single-hop	➢ Giving sensor nodes with remaining power a better probability of becoming a cluster head.	➢ Stabilizes the network power usage. ➢ Maximizes the network lifespan.
Improved Multi-Hop Leach	Dynamic	Yes	Multi-hop	➢ Uses both intra and inter-cluster communication. ➢ Position the cluster head and substitute its cluster head as required.	➢ Balances the power intake of a system. ➢ Prolonged the network lifespan. ➢ Lowering the loss rate and maintaining connection.
EAERP	Dynamic	Yes	single-hop	➢ Using the fitness function to recognize cluster routes that decrease the network's general power losses. ➢ Distinct power of cluster heads is utilized at each round but at regular periods.	➢ The Grouped routes enhance the steadiness among stability of the network and system lifespan. ➢ Confirm that power is uniformly shared
TL-LEACH	Dynamic	Yes	Multihop	➢ Uses slave and master stages of cluster heads.	➢ The no. of communicating nodes should be minimized. ➢ Reduces the total energy intake.

MR-LEACH	Dynamic	Yes	Twohop	➢ Form various layers of groups inside the system. ➢ Equal clustering.	➢ Minimizes the power intake.

Debashish, Sravani, & Rajesh, (2023) proposed to inspect a hierarchical and dispersed method for routing wireless sensor network traffic and simultaneously executing the grouping and multi-hop directing procedures. Their method minimizes the amount of packets and is then compared with the LEACH-based algorithm, therefore, commonly renowned and used algorithm herein the field. Outcomes show that the study certifies that the proposition of power safeguarding improves the durability of the network lifetime. Sharma *et al* (2023) presented a novel route method that discovers an optimum route used for sending information feedback to sink using the grouping method. Difference toward the universal route algorithms like the DEEC, SEP, and LEACH respectively, the proposed one unveils a noticeable improvement. After being related to standard procedures, the proposed paper displays at least 51% enhancement of the whole network and includes network lifetime, stability period, average power consumption, and throughput.

Roja & Pranay (2021) offered research that increases network lifespan while minimizing power usage called the MAX LEACH algorithm, based on media access control (IEEE 802.15.4) routing, and was applied inside the offered study employing a computer hardware called the SENSEnuts. The study shows the SENSEnuts exposed to the MAX LEACH method compared original LEACH protocol show a significantly improved network lifetime by a 50.2% increase. To assure accuracy the SENSEnuts were utilized to observe the ambient situations like lighting and temperature.

Evolved in cluster creation and helping in decreasing power intake, the recommended result was to address the network challenges linked to trouble-spot challenges and prolong the network lifespan. The research was related to the advanced techniques of the LEACH algorithm and shows that it improved the remaining energy in the network, reduced losses in packet delivery, and enhanced the network lifetime (Veerendra & Mallikarjuna, 2020).

Yongfan *et al* (2019) introduced an enhanced revised form of a LEACH algorithm which used a fuzzy logic method (LEACH-FIS) to decide which node will be selected in place of the cluster head, then After comparing it with LEACH-ME, MBC, and LEACH-M, the lifespan of LEACH-FIS increases the network performance by 22.5%, 66.2% and, 52.7%, in turn.
Dimple *et al* (2019) proposed an examination of disparities in diverse cluster-based routing methods used in improving the efficiency of wireless networks. Therefore, the grouping procedures, information integrating, and CH allocation made probable by clustering techniques are very vital for prolonging a network lifespan in wireless sensor networks. Their proposed method employs a variation of the LEACH protocol to aid the early phases of CH selection, and then the durability and cluster plan of the network are equally enhanced.

Fang & Junfang (2019) offered the use of unequal grouping techniques to resolve with hotspot problem and proposed a dual CH method to reduce the energy usage by the cluster heads. Moreover, a crossbreed CH cycling method centered on both power and focussed on time ethics is suggested to stabilize the power intake between CH and sensor nodes. This crossbreed method can increase power effectiveness and moderation in time cycling. Lastly, they simulate the research and relate the offered method to UCNPD, DEBUC, and LEACH respectively. The outcomes confirm that the presented method considerably increased the efficiency of the network in crucial areas like network lifespan, stability, availability, throughput, and power effectiveness respectively.

3.0 Problem Statement

Concerns associated with wireless sensor networks are nothing but the delivery limitations at the time of usage, like the cost, size, and residual energy. Specified the challenges of gaining access to sensor nodes in their normal locations, we focus on resolving the challenges of energy intake which is the greatest persistent worry on how to extend a network lifetime. Sensor nodes donate to wireless sensor networks by archiving configurations and gathering information from the immediate surroundings. Numerous very vital areas profit from this, including but not limited to habitat, earthquakes, volcanoes, and oceans. Virtual reference stations (VRS) assist in guiding packets of data to a target receiving end in an effective way that uses the minimum power needed. That will exclude the likelihood of losses in packet transfer. Additionally, the LEACH protocol continuously preserves power by reallocating the CHs dependent on the residual energy of the SNs. The assistance gained in joining the LEACH protocol and virtual reference station will permit us to resolve their distinct weaknesses.

4.0 Proposed Methodology

The proposed research uses sub-LEACH tools to decide which sensor has a greater effect on the group. The discrete sensor node power level defines how significant that sensor node is in the entire network. Therefore, the CH necessarily attains energy weightage and Euclidean distance. A cluster head is selected centered on its comparative location relative to a prearranged weighting condition. While defining a sensor node's weightiness, the main objective is to certify that it can efficiently represent responsibilities ordinarily executed by the CH. The collective information-sending power must be determined.

Also, the study is attentive to dual low-energy algorithms named Sub-cluster LEACH, original LEACH, and MFO are together applied individually to enhance network efficiency. Power effectiveness, throughput, and propagation delay are some quality of service pointers to evaluate the effectiveness. MFO merged with Sub-cluster LEACH was determined to do better than other opposing procedures in the results simulated.

4.1 LEACH Protocol

The LEACH protocol is an important ranked grouping procedure for wireless sensor networks, it was established to decrease energy intake inside the network. The ranked organization of the LEACH algorithm is erected based on scattering of sensor nodes through several groups, through every cluster picking a sensor node to function as cluster head centered on a possibility sharing (Heinzelman & Chandrakasan, 2000). The LEACH procedure is broadly divided into two separate portions: the first is the initialization portion and the second is the stable stage portion. Group creation in addition to sensor recognition, used for cluster head are all together are portion of the initialization stages. The next stage of the LEACH protocol involves initially detecting their particular surroundings and sending that data to CHs, then sending the information in packets to BS in agreement with the hierarchical method of sharing arrangement (Falko & Roman, 2012). Selection of CH is built on the possibility distribution, through every sensor node making random figures between 0 & 1 at the start of every cycle. Each node will not become a cluster head in every round, and if its energy level is lower the set value (Th (N.S)). Nevertheless, if a random figure surpasses a set value, a node will be placed to be CH on its predictable length after the neighboring cluster head node. The subsequent formula was used to calculate the threshold value, Th (N.S).

$$Th(N,S) = \begin{cases} \frac{Per}{1-Per\times(Ro \bmod \frac{1}{Per}} & N.S < S \\ 0 & Others \end{cases} \quad (1)$$

N.S. at this juncture represents the entire sum of SNs inside the sensor field.

Per means the expected segment of nominated cluster head relation to entire sensors nodes.
Ro is the value of a present cycle.
S signifies the group of normal sensor nodes or 1/per cycle in some cases.

Ever since the LEACH procedure chooses cluster head nodes without concern for the remaining power of the sensors, occasionally a cluster head is selected that lacks the properties to effectively receive and send information by another sensor participant in the group to the base station (Taspia & Sharif, 2020). Therefore, the recommended technique uses the residual energy of the sensor node as a vital condition for the selection of subsequent cluster heads, causing effective sharing of power used all over the network and, as a result, a lengthier lifetime for the network. In the group creation steps, the LEACH algorithm arranges all non-cluster head sensors with the cluster head, contingent on being close to the immediate neighbor. The suggested method similarly uses a distance constraint among the sensor nodes and the cluster head to decide which sensor nodes fit the appropriate groups. While the sensor is distant away the BS, the offered procedure uses a multi-hop method for information sending, however, if the sensor is closer to the BS, then it changes to a single-hop method. These methods reduce the load on the sensor node energy letting sensor nodes from different groups begin groupings and transmit data to the BS without allowing over any in-between sensor nodes.

Supposing that sensors are homogeneous setup collapse into dual groupings, then they altogether report to the single central base station, then permitted us to come up with the resultant hierarchical arrangement. The initial category of sensors node stances for the entities that contain a group. Another kind of sensor node is the cluster head, the sensor that serves as an accumulator to store packets of data transmitted through supplementary nodes which are also group participants and convey these packets to the base station. To ensure the proposed method has a worthy shot at functioning without restrictions from some boundaries, the following assumptions were made about the apparatus and the location of the sensors as they are positioned.

1. The devices cannot be relocated once connected.
2. The home-based base stays firmly set up.
3. All sensor nodes have similar capacities at starting and processing (homogenous) in the network.
4. A GPS probe was not used for these sensors.
5. A sink was unhindered to processing energy, memory storage, and additional characteristics.
6. The batteries of the sensors cannot be replaced or recharged once they are employed and they do not collect any extra energy improvement once installed.

The set of rules following are drives over the fundamental phases of a recommended technique:

Step 1. The sensor field consists of 100 sensors randomly distributed and the base station (BS) covers an area of 100 × 100-metre square.

Step 2. The site of the BS broadcasting requests (data packets) is transmitted to the sensor nodes (SN) in the nearby region.

Step 3. Once getting an invitation from the BS, the SN will reply by transmitting a message that comprises its identity, residual energy level, and position.

Step 4. All sensors in the field will discover how distant they are from the BS and batteries' residual energy.

Step 5. The BS chooses what sensor to use as cluster heads after each round by relating a random digit created by each connection in the network to the threshold value (centered on the residual power of the nodes).

Step 6. The cluster head sends a notification to their immediate neighboring sensor nodes so that they arrange themselves into groups according to distance from the BS.

Step 7. All the sensors will begin sending information to their cluster head if the range between it and its cluster head is smaller than the range between it and its base station. If this is the situation, then the cluster head will assign a time division multiple access (TDMA) control.

4.2 Sub-cluster LEACH procedure focussed on the IPEE technique

Sub-cluster LEACH procedure is the title of the projected technique. The base station initializes the network's widespread information request, in this technique, and the whole network afterward shapes the grouping bestowing the remaining power of SN and the sensor node's attention. CHs are sensor nodes that have an essential part in taking together their clusters. That shows how clustering is done in the LEACH procedure; the cluster head selects two additional SNs, the Subcluster head nodes, to assist as cluster heads. The Sub cluster head executes roles equal to that of the cluster head, with the exclusion of the last node reply. Because the fact is that the sub-cluster head only responds to the cluster head. Here and now, an efficient technique for choosing cluster heads is required to maximize power effectiveness to an advanced level. Consequently, the LEACH algorithm for selecting the cluster head is prolonged to contain the IPEEs (Mittal (2022).

4.3 Sub-cluster LEACH procedure focused on the MFO algorithm

The MFO technique is realized as a sub-cluster LEACH procedure. That means the information request was transmitted from the BS. Afterward t, the network necessity governs absolutely whether is the first round or not. If it is true then the entire SN power necessity to be assessed earlier to the selection of the CH is completed, or else, the procedure necessity halt. Entirely, the sensor nodes have a uniform power level at the initial round. Moth flame optimization and the illustrations if the SN is resolute to be cluster head. The load of gathering and arranging a huge size of information falls excessively on the cluster head. Selecting a sub-cluster head from amongst the number of cluster heads is achieved through the usage of the Moth flame optimization (MFO) technique. Therefore, the Sub-cluster heads and cluster heads accomplish the accumulation and broadcast of information succeeding in the finalizing of the election process. Resulting, the power stages of every sensor node are assessed. Each sensor node is entitled to the successive round if its power level surpasses a convinced threshold value; or else, it is considered to have died and cannot be regarded as a member of the network.

4.4 Delay Analysis

The following equation offers the ratio of delay analysis:

$$Delay_{E-to-E} = \frac{\sum(\theta - \alpha)}{N}$$

Where N = number of connections, α = sending time, and θ = arrival time. the prearranged formula will make the manipulation of the delay easy. If the time is shorter, it takes for a procedure to accumulate information at the cluster head and transmit information to the base station. Like so, the effectiveness may be measured for any procedure that can be enhanced to accelerate information collection and broadcast to the BS. Altogether the six algorithms had their delay calculated from starting to the end and all of the delay was computed afterward every iteration.

4.5 Packet Delivery Analysis

Once associated with the number of packages sent and then acknowledged, the packet delivery ratio (PDR) remains the straight point of system efficiency. Once the packet delivery ratio (PDR) advances, and then system effectiveness trails. The formula to find the packet delivery ratio (PDR) below:

$$PDR = \frac{\sum N_R}{N_s}$$

N_R = No. of packets incoming, and N_S = No. of packets outgoing.

5.0 Experimental Result and Discussion

This segment defines projected outcomes tests and trial arrangements. The graph and table represent the outcome of the results respectively.

5.1 Experimental setup

The MATLAB 2017 software type was used to simulate the proposed scheme. Table II comprises the detailed information.

Table II. Network Parameters

Parameter	Value
Length of packets	200 bits
Length of data packet	4000 bits
CH probability	0.1
Maximum number of rounds	2000
Electronics Energy	50 nJ/bit
Battery energy	0.5 Joules
Field Dimensions	$100m^2$
Energy model parameter: of sfs	10pJ/bit/m2
Base Station	Centre of the field
Energy model parameter	0.0013pJ/bit/m4
Number of nodes	100

5.3 Network Lifetime

The lifetime of a network means the time through which the system can accomplish its distinct objective and it signifies a significant system of measurement to assess the cluster head election method and energy consumption. Figure 1, displays that our projected IPEE-LEACH algorithm permits improved efficiency of alive nodes during the simulation if related to LEACH, as a result of the power intake being equally dispersed between all the sensor nodes. IPEE-LEACH splits the network into sub-regions and evades redundant implementation of cluster head selection procedure into grouped segments. the presented methods stabilize energy consumption between all the sensor nodes. Nevertheless, in LEACH, the casual selection method of cluster head selection doesn't enhance the preservation of power between sensor nodes and decreases meaningfully the network lifespan

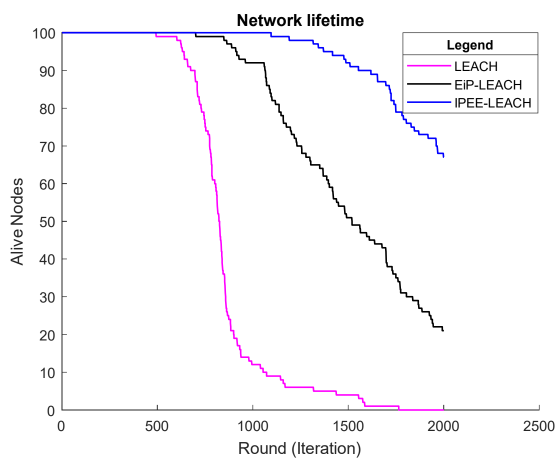

Figure 1, The Network Lifetime

The lifespan of the network is shown in Figure 1, with an area of $100m^2$. Equally, the diagrams prove the dominance of the proposed Sub-LEACH-MFO and IPEE-LEACH procedures over other algorithms concerning network lifetime. The algorithm combines IPEE-LEACH and MFO procedures, whose goal is to reduce the burden on the system by pointing information to a selected cluster of sensor nodes, like a cluster head or a sensor. The entire lifespan of the network relies on how widely energy is managed whereas the network is working and information is being transmitted. To find out which following round of the cluster head has the most remaining power and is closest to the base station, the LEACH algorithm deploys IPEE and MFO methods. Thus, prolongs the lifetime of the system generally. Sub-LEACH usages the IPEE and MFO in a similar technique, the previous aids in choosing a node that is neighboring to a CH, and the last assists as a sub-CH to minimize the power intake of the CH. The proposed work also used the last node dead (LND) as a reference to lifespan measures for the system after 2000 successful rounds, in LEACH protocol the LND at 1762 rounds with 0 alive nodes, in EiP-LEACH after 2000 rounds with 21 alive nodes, and in IPEE-LEACH after 2000 round with 67 alive nodes. Furthermore. Together IPEE-LEACH and Sub-LEACH-MFO meaningfully censored their batteries' energy requirements. That suggested that together IPEE and MFO are efficient approaches for selecting sub-cluster heads and cluster members. Overcrowding organization from cluster head to the BS is likewise taken into consideration. Consequently, the average lifetime maximizes.

5.4 Steady State

A steady state signifies the time between the start of the network to the time when the first sensor dies IPEE-LEACH ranges steady state due to its subdivision of nodes into smaller areas and effective reorganization procedure. Simulated outcomes are shown in Figure 1.

The network stability time signifies the time when the system retains its early network topology before the first node dies. IPEE-LEACH spreads its steady time due to its regrouping of sensors to reasonable sections and effective cluster head reassignment procedure. Results simulated shown in Figure 2 show the network lifespan by displaying the evaluation of numerous dead nodes during the evaluation procedure. In LEACH protocol, the first node dies at 470 rounds, EiP- LEACH the first node dies at 701 rounds and in IPEE-LEACH the first node dies at 1095 rounds respectively.

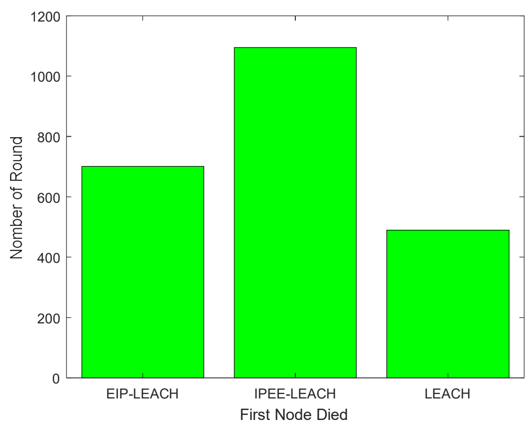

Figure 2, Network Stability

5.5 Energy consumption

IPEE-LEACH harvests less energy consumption compared to LEACH. Figure 3, visibly describes that our procedure outdoes the LEACH algorithm in relation to energy intake per iteration. Therefore, the improved approach for the election of cluster heads, besides the network grouping into sub-groups, permits to enhancement of the energy intake of the network in an extraordinary way. The energy level of LEACH protocol decreases to 0.002243 Joule (J) after 1269 packets transfer, EiP-LEACH decreases to 0.008914J after 2000 packets Transfer and IPEE-LEACH remains at 0.07401J after 2000 packets transfer.

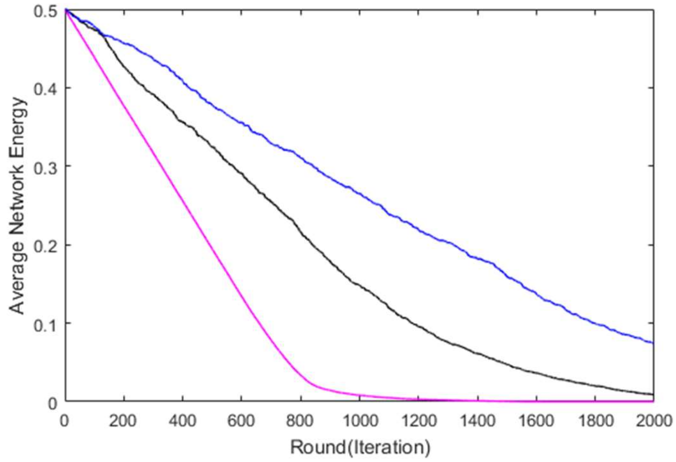

Figure 3, Energy Consumption

6.0 Conclusion and Future Work

we explore and examine numerous wireless sensor network procedures in this study with an emphasis on LEACH-founded clustering methods for improving power effectiveness and prolonging the lifespan of wireless sensor networks. The growing request for information gathering in isolated and challenging surroundings demands a ground-breaking approach to preserve power and extend the network process like time and data, the simulation result has confirmed that IPEE outdoes other algorithms, contributing substantial enhancements in the network lifespan and general performance of the network.

Some recommendations were made after the research for forthcoming research, we extra examine and modify the procedure and discover more optimization methods to improve power effectiveness and network steadiness. Moreover, we design to enlarge our research to a bigger network field and reflect on extra constraints to increase a deeper thoughtful of the procedure's efficiency under varied situations. Moreover, we will discover novel techniques to attack the problems associated with real-time information broadcast and effective information accumulation in wireless sensor networks, eventually helping the progression of power-effective and dependable wireless WSNs for countless areas of application.

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