Improving S-LEACH protocol of UWSN for Real-time Underwater Observation Technique for Freshwater (River/Lake)

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Abstract

The goal of this study is to design the Enhanced Sun Based Low Energy Adaptive Clustering Hierarchy protocol (ESBLEACH), which can increase the network lifetime in Underwater wireless sensor networks (UWSNs) by minimising the amount of energy used. Here, solar energy (photovoltaic) is utilized for energy harvesting with external powersources to the sensor nodes. This solar-powered external power system is used to extend UWSNs' network lifetimes. The major goal of the suggested technique is to choose efficient routes to a terminal as well as cluster heads (CHs). The proposed approach integrates two main procedures, namely the Coati Optimization Algorithm (COA) based leach protocol for multi hop routing. The COA approach choose CHs in addition systematizes clusters related on dissimilar constraints like absorption loss, spreading loss, propagation sound, ambient noise, signal-to-noise ratio, transmission loss, and propagation delay. Using performance metrics like Network lifespan, total energy usage, and other metrics, the suggested approach is implemented in MATLAB, and its effectiveness is evaluated. The proposed method is compared to more established methods like the LEACH protocol and the LEACH protocol with Particle Swam Optimization (PSO), respectively.

Keywords: *solar-based low energy adaptive clustering hierarchy protocol, network lifetime, cluster head, coati optimization algorithm, and absorption loss.*

1. Introduction

UWSNs are comprised of a significant count of underwater wireless sensor nodes that are disseminated all through the marine environment. UWSNs help collect data [1], navigate, look into sources, track activity, and anticipate calamities. Due to the usage of batteries with insufficient capacity and the challenges associated with replacing or charging the built-in batteries, energy efficiency becomes a significant issue as UWSN technology advances [2]. Prior research suggests that the UWSN may leverage routing and clustering to achieve energy efficacy. Metaheuristics is used to tackle nondeterministic polynomial-time (NP) hard optimization issues including clustering and routing. Because according to their vast variety of application areas [3,4], counting ecosystem nursing, catastrophe risk reduction, secondary navigation, and other fields, UWSNs are becoming more and more popular in business as well as academia [5].

The domain of UWSNs has recently garnered considerable interest as a result of strong, distinctive techniques in undersea surveillance, ocean monitoring, marine surveillance, and development services for detecting underwater benchmarks. A UWSN is comprised of a mobile sink, ground stations, and sensor nodes [6]. All the sensor nodes inside the Underwater communication are dispersed throughout the water, mostly after the outer to the ignoble. The data is principally gathered and sent to the mobile sink, which then sends it on to the base station. Sensors keep an eye on the shallow water habitat [7], counting the temperature, in addition send the information they gather to a sink node across one or more hops. Earlier works have released an array of directive protocols whichreflect underwater data sharing via audio energy [8] and their disadvantages, such as a high failure rate, propagation delay, as well as other issues [9].

The main objective of the designed protocols has been to extend the network's life. Routing needs to balance energy usage since sensor devices make it incredibly hard to swap out the sensor node battery and recharge [10]. Noncooperative data transfer or data transfer using a single node are the 2 techniques accessible for transmitting information from the source to the destination. The second method involves using relay nodes in place of a single node or collaborative communication. In these networks, cooperative interaction is the most effective technique to reduce data errors and offer dependable communication between both nodes. Cooperative communication sends data across a variety of paths to increase the likelihood that its recipient would correctly get it. The routing protocols are intended to improve lifespan efficiency.

The remainder of the page is already set up as shadows, and section 2 explains how everything is related. Section 3 offers the intended architecture and an explanation. Section 4 provides information on the expected methodology's performance. In section 5, a summary of the study is provided.

2. Recent Research Works: An Overview

In the literature, a few works are reviewed in this section. Routing-based approaches for empowering the lifetime of the UWSNs are reviewed in this section.

To solve the bulk of these problems, Manal Al-Bzoor*et al.* [11] presented the Directional Selective Power Routing Protocol (DSPR). The best route to the surface sink was calculated either by the proposed protocol using the sender depth data and angle of arrival. Furthermore, the DSPR employs discerning power regulation toempower ensure connectivity, and reduce energy consumption and the delivery ratio. Several simulation studies have been carried out to verify the effectiveness of the proposed regimen. Based on the findings of the simulation, the suggested DSPR protocol outperformed two variations of the traditional protocols in terms of energy consumption and delivery ratio.

Ibtihal Ahmed Alablani et al. developed the Energy-Efficient protocol for UWSNs [12], a unique MAC/routing protocol for UWSNs (EE-UWSNs). To bar sensor energy and increase the lifespan of UWSNs, it was built on five guiding principles. These recommendations include utilizing finite power quantities, the use of multi-hop transmission, restriction of the transmission's range, the use of inactivation mode, and balancing energy consumption.

The cooperative energy-efficient routing (CEER) protocol was introduced by Irfan Ahmad et al., [13] to extend network life and create a reliable network. Here, throughreducing the hotspot issue, the sink mobility scheme lowers energy consumption. For better deployment, the area has been divided into several portions, and the sink nodes have indeed been put in each section. To save energy, the sink receiver receives the data from sensor nodes and processes it. Here, the cooperative method has also been applied to ensure network reliability.

Jitander Kumar Pabani et al. [14] have developed an energy-efficient packet forwarding strategy utilising fuzzy logic with the goal of improving the energy economy of UWSNs. Three metrics are used in the proposed protocol: the length of a 3D UWSN design (or its associated received signal strength pointer, RSSI), the number of clusters (within a node's transmission range), and the number of hops required reaching the gateway node. The system's performance is further confirmed using adaptive and quasi-transmission times as well as an ascendable count of nodes in order to assess the impact on energy consumption and the number of hops.

Huma Hasan Rizvi et al. [15] have provided an energy-saving solution for UWSNs that fully utilises the LEACH calculation method. According to simulation findings comparing the projected cluster formation approach for UW networks with the hierarchical clustering methodology of LEACH for terrestrial networks, the projected strategy for UWSNs competes with that of LEACH for terrestrial WSNs. The proposed approach, which is comparable to the LEACH procedure, extends the life of the UWSN and lowers total energy usage. Every time, the number of active nodes and the network's lifespan stay constant.

3. Proposed Architecture

The purpose of this research is to introduce an ESBLEACH for reducing the consumed energy leads to enhancing the network lifetime in UWSNs.Additionally, this technique is developed for empowering energy efficiency. This proposed technique introduced a COA-based leach protocol and formed the cluster efficiently. After that, the LEACH protocol is a routing approach and COA is utilized for selecting CH. This approach is considering multi-objective functions by using different functions such asabsorption loss, spreading loss, propagation sound, ambient noise, signal-to-noise ratio, transmission loss, and propagation delay. The architecture of UWSNs is presented in figure 1.

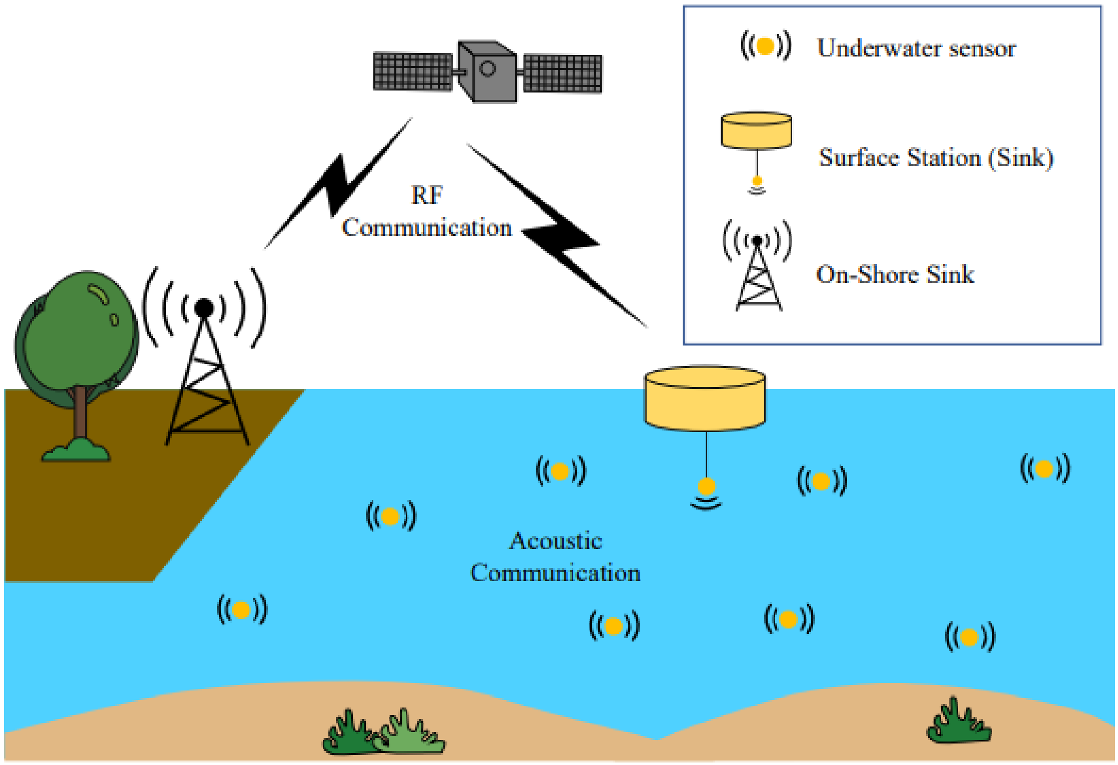

Figure 1: System Architecture

Here, solar energy is utilized for energy harvesting with external powersources to the sensor nodes. The network lifespan of UWSNs is powered by this solar-based external power system. Selecting cluster heads (CHs) and the optimum routes to a terminal is the major goal of the suggested strategy. The proposed approach joins two main procedures, explicitly the COA-based leach protocolfor multi-hop routing. The COA technique selects CHs and organizes clusters based on various limits like absorption loss, spreading loss, propagation sound, ambient noise, signal-to-noise ratio, transmission loss, and propagation delay. The following are specific explanations of the proposed strategy,

3.1. Multi-objective function

In the UWSN, transmission is a critical parameter for enabling efficient communication. Different parameters are considered in the transmission of UWSN such as absorption loss, spreading loss, propagation sound, ambient noise, signal-to-noise ratio, transmission loss, and propagation delay [16]. To achieve efficient transmission in UWSN, the multi-objective function is considered. The objective function is formulated as follows,

$$OF = Min(AL + SL + AN + SNR + TL + PD) \qquad (1)$$

Here, PD is defined as the propagation delay, TL is defined as transmission loss, SNR is defined as the signal-to-noise ratio, AN is defined as ambient noise, SL is defined as the spreading loss and AL is defined as the absorption loss.

3.1.1. Absorption loss

It is defined as the energy loss and its formation of heat because of ionic relaxation and viscous friction which happens as the sound wave propagated outwards underwater. It is formulated as follows,

$$AL = \alpha \times R \times 10^{-3} \qquad (2)$$

Here, R is defined as the transmission range in meters, and α is defined as attenuation in dB/km.

3.1.2. Spreading loss

It is a particular type of transmission loss that takes place as sound moves away from the source and destination [17]. The formula for this spreading loss is as follows:

$$SL(R) = K \times 10 \log(R) \qquad (3)$$

Here, K is defined as the spreading factor.

3.1.3. Ambient noise

It is a type of UWSN noise that is quantified by adding together thermal, wave, shipping, and turbulence noise.

Thermal noise: $10\ logn_{th}(F) = -15 + 20 \log(F)$ (4)

Wave noise: $10logn_w(F) = 50 + 7.5\sqrt{w} + 20 \log(F) - 40 \log(F + 0.4)$ (5)

Shipping noise: $10logn_s(F) = 40 + 20(s - 0.5) + 26 \log(F)$ (6)

Turbulence noise: $10\ logn_t(F) = -17 + 30 \log(F)$ (7)

3.1.4. Signal-to-noise ratio

It is referred to as the background noise-related signal intensity. The signal-to-noise ratio is computed as follows,

$$SNR(L,F) = \frac{P(L)}{(n(F)a(L,F)b(L))} \qquad (8)$$

Here, $a(L,F)$ is defined as the attenuation level and $n(F)$ is defined as the noise level,

3.1.5. Transmission loss

The sound strength is reduced throughout the course of the architecture from the transmission node to the achieving node. Broadcast diversity and decrease affect transmission loss. According to the following definition,

$$TL = SS + \alpha \times 10^{-3} \qquad (9)$$

$$SS = 20 \log R \qquad (10)$$

Here, SS is defined as the spherical spreading factor and α is defined as the attenuation factor.

3.1.6. Propagation delay

It is defined as the amount of time the signal needs to travel from the transmitter to the receiver. It is formulated as follows,

$$T_P = \frac{D}{C} \qquad (11)$$

Where C is defined as the sound in meters and D is defined as the distance among nodes.

3.2. EnhancedLeach protocol

In this paper, a brand-new method for integrating the COA with the LEACH routing protocol is developed. This LEACH protocol consists of a collection of cluster head-related parameters. With COA's support, it is chosen. With the consideration of the multi-objective function, the COA is select the efficient cluster head. The cluster head is first selected by taking the Euclidean distance into account. Based on the weights given to the nodes, the cluster head is selected. The energy stage of the particular sensor node determines the node weighting. Here, cluster head combined with the Euclidean distance also compensatesfor the energy weightage [18]. The cluster head is deleted only when it is above the weightage parameter considered. The major objective of the constant weightage node should be to manage the process of the cluster head. The energy is necessary to transmissioninformation in the UWSNs. The energy requirement of the cluster head is chosen based on the below equation,

$$e_{ch} = N\left(K * \left(e_{elec} + e_{fs} * D^2\right)\right) \qquad for\ D < 0 \qquad (12)$$

$$e_{ch} = N\left(K * \left(e_{elec} + e_{amp} * D^2\right)\right) \qquad for\ D \geq 0 \qquad (13)$$

Where, D is defined as the transmitting distance to the sink node, e_{amp} is defined as the variable for computing the L-bit message transferring over free space multipath propagation, e_{fs} is defined as the variable, e_{elec} is defined as the energy necessary for receiving and sending data bits, K is described as the number of message bits, N is described as the number of nodes managed for the cluster and e_{ch} is defined as the energy consumed by the cluster. In the LEACH protocol, the clustering is achieved by considering the Euclideandistance, which is presented as follows,

$$D\{Y_I, H_C\} = (Y_I - H_C)^2 \qquad (14)$$

Here, D is defined as the Euclidean distance function.

3.2.1. Coati Optimization Algorithm

In this proposed methodology, the optimal cluster head is selected by using COA. Coati is named coatimundis and based on their behavior; an optimization technique is developed. In this paper, the optimal solution is chosenthrough considering the COA. The method of the coatis wasaggressive the iguanas in additionthese characteristics. This characteristic is associated with the predator's efficient procedure. The processing of this general coatis' characteristics is the general inspiration for developing this COA technique [19]. The location of every coati in the search location computes the parameters of the decision parameters. A potential remedy for the problem is described at this COA site. The coatis' location in the search area is reset when the COA execution process first starts by taking into account the equation below.

$$x_I = x_{I,J} = LB_J + R.\left(UB_J - LB_J\right), I = 1,2,..,n: \ J = 1,2,..,M \qquad (15)$$

Here, UB_J is described as the upper bound of the decision variable, LB_J is described as the lower bound of the decision variable, R is defined as the random real number of the period [0,1], M is defined as the count of decision parameters, n is described as the number of coatis, $x_{I,J}$ is described as the parameter of the decision parameters and x_I is defined as the position of the ith coati in search space. The initialization of the coati is presented as follows,

$$x = \begin{bmatrix} x_1 \\ \cdots \\ x_I \\ \cdots \\ x_n \end{bmatrix}_{n\times M} = \begin{bmatrix} x_{1,1} & \cdots & x_{1,J} & \cdots & x_{1,M} \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ x_{I,1} & \cdots & x_{I,J} & \cdots & x_{I,M} \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ x_{n,1} & \cdots & x_{n,J} & \cdots & x_{n,M} \end{bmatrix}_{n\times M} \qquad (16)$$

Based on the objective function, the various parameters are considered with decision parameters. The updating procedure of the coatis is designed with two characteristics coati technique when aggressive iguanas and the coati seepage technique from predators. This hunting and attacking technique on iguana are presented as follows,

$$x_I^{p1}: x_{I,J}^{p1} = x_{i,j} + R.\left(Iguana_J - i.X_{I,J}\right), for\ i = 1,2,\ldots,\left[\frac{n}{2}\right] \ \ and\ J = 1,2,\ldots,M \qquad (17)$$

The iguana is at a chance spot in the search area after it falls to the earth. Coatis are the ground motion in the search space in relation to this arbitrary position, which is still expressed as follows:

$$Iguana^g: Iguana_J^g = LB_J + R.\left(UB_J - LB_J\right), \ J = 1,2,\ldots,M \qquad (18)$$

$$x_I^{p1}: x_{I,J}^{p1} = \begin{cases} x_{I,J} + R.\left(lgunana_J^g - i.x_{I,J}\right) & f_{lgunana^g} < f_I \\ x_{I,J} + R\left(x_{I,J} - lgunana_J^g\right) & else \end{cases} forI = \left[\frac{n}{2}\right] + 1, \left[\frac{n}{2}\right] + 2, \ldots., n\ and\ J = 1,2,\ldots,M \qquad (19)$$

If the new location increases the parameter of the impartial function, it can satisfy the inform method for each coati. The following is how this update process is presented:

$$x_I = \begin{cases} x_I^{p1} & f_I^{p1} < f_I \\ x_I & Else \end{cases} \qquad (20)$$

Here, $Iguana^g$ is defined as the location of the iguana on the ground, $f_{lgunana^g}$ can be described as the objective function, $lgunana_J^g$ is defined as the dimension, I is defined as the integer that can be randomly chosen from the pair {1,2}, R can be described as the random real count in the interval [0,1], f_I^{p1} is described as the objective function parameter [20], $x_{I,J}^{p1}$ is defined as the dimension and x_I^{p1} is defined as the novelpositioncalculated for the coati.

Algorithm 1:

Initiate COA
Set the random weighting parameter.
Select the count of coatis and set the count of iterations.
Initialization of the coati's position and calculation of the objective function in the initial population
For $T = 1{:}t$
    Update the location of the best population.
Hunting and attacking technique
    For $I = 1{:}[N/2]$
Compute the new location of the coati.
Update the position of the coati
End for
    For $I = 1 + [N/2]{:}n$
    Compute random position for the ith coati.
Update the position of the coati.
End for
The procedure of escaping from predators
Compute the local bounds for the variable.
For $I = 1{:}n$
Compute the new position of the coati.
Update the position of the coati.
End for
Store the optimal solution.

End for

The output of the optimal achieved solution by COA

End

A second step is the process of fleeing from predators. After that, position updating of coatis in the search location can be designed related on normal characteristics of coatis when meeting predators in additionabsconding from predators. To process the characteristics, a normal position is created close to the position in that coati can be located related tothe below formulation,

$$LB_J^{local} = \frac{LB_J}{T}, UB_J^{local} = \frac{UB_J}{T} \; here, T = 1,2, \ldots t \qquad (21)$$

$$x_I^{p1}: x_{I,J}^{p1} = x_{I,J} + (1-2R).\left(LB_J^{local} + R.\left(UB_J^{local} - LB_J^{local}\right)\right) \quad I = 1,2, \ldots n, J = 1,2, \ldots, M \qquad (22)$$

The afresh computed location is satisfactory when it enhances the parameter of the objective function which this scenario executed by by means ofthe below equation,

$$x_I = \begin{cases} x_I^{p2} & f_I^{p2} < f_I \\ x_I & Else \end{cases} \qquad (23)$$

Where, LB_J is described as the lower bound of the decision variable, UB_J is described as the upper bound of the decision variable, LB_J^{local} is defined as the local lower bound, UB_J^{local} is defined as the local upper bound, R is described as the random parameter in the period [0,1], f_I^{p2} is defined as the objective function variable, $x_{I,J}^{p2}$ is defined as the dimension, x_I^{p2} is defined as the new position computed for the coati with the relation of the next phase of COA.

4. Outcome Validation

This portion elaborates on the validation of the proposed method by comparison and performance analysis. This projectedapproach is industrialized for attractive the energy-efficient approach in UWSNs with the consideration of different parameters. The projected approach is applied in MATLAB in the 2018a version, and this system consists of 8GB

RAM, core i5 system, and 5th generation. The implementation variables of the projected approach are given in table 1.

Table 1: The variables for simulation

S. No	Description	Constraints
1	Number of nodes	50
2	Number of rounds	1000
3	Net size	300
4	Eo	0.5
5	Number of iterations	500

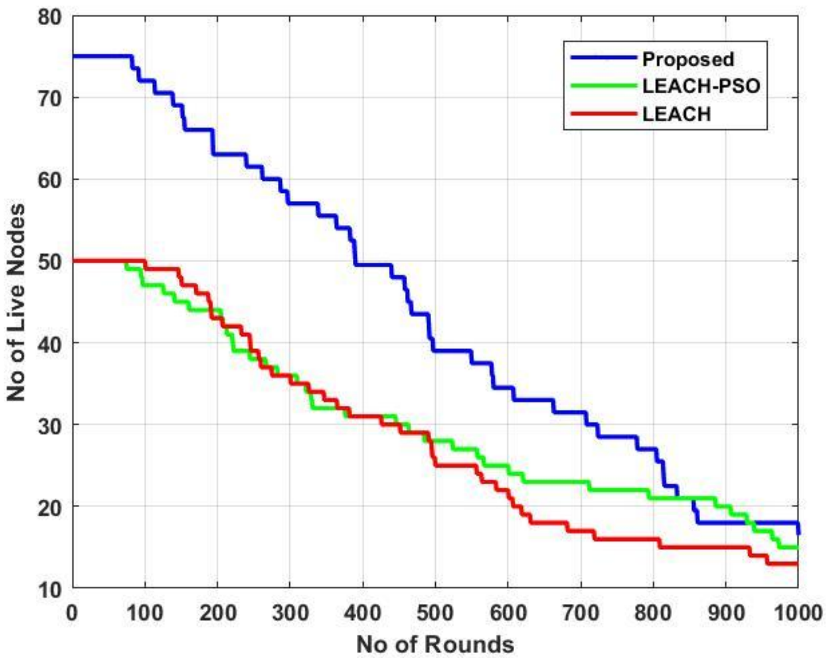

Figure 2: Number of live nodes

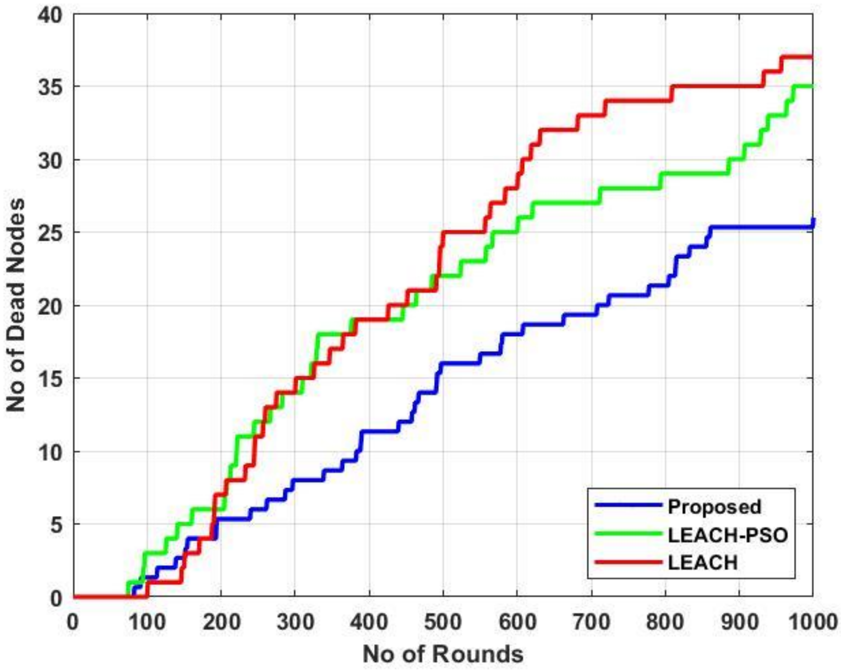

Figure 3: Number of dead nodes

By taking into account the quantity of active nodes, the planned technique is validated. Traditional approaches like LEACH-PSO and LEACH are compared to the predicted strategy. Using the quantity of rounds, the amount of live nodes is verified. During 200 rounds, proposed method has 70 live nodes. Similarly, in the various rounds of 200 and 300, the proposed method has 65 and 60 live nodes. The conventional techniques of the LEACH protocol have 50 and 48 live nodes during 100 rounds.When compared with the conventional techniques, the proposed approach achieved a high count of live nodes. The proposed approach is validated by considering the count of dead nodes. The proposed method is compared to more established ones like LEACH-PSO and LEACH. The number of rounds is used to verify the amount of dead nodes. During 1000 rounds, the proposed method has 25 dead nodes. Similarly, in the various rounds of 800 and 900, the proposed method has 22 and 24 dead nodes. The conventional techniques of LEACH protocol have 35 and 37 dead nodes during 1000 rounds. When compared with the conventional techniques, the proposed approach achieved a low count of dead nodes.

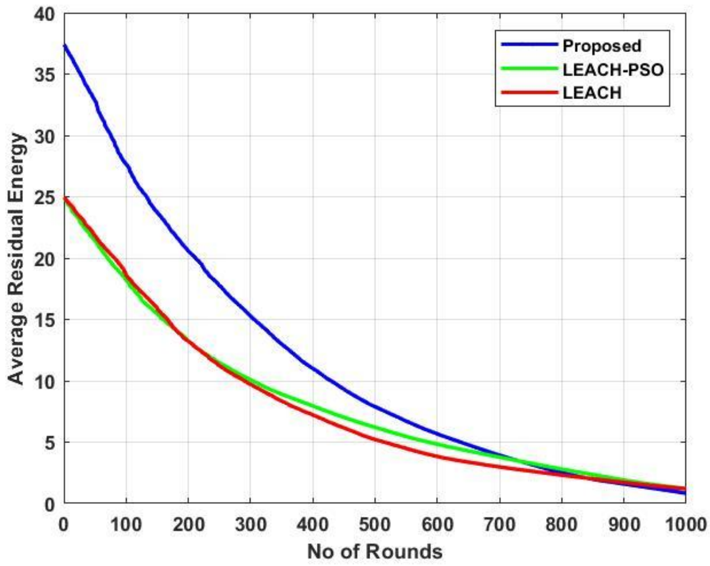

Figure 4: Average residual energy

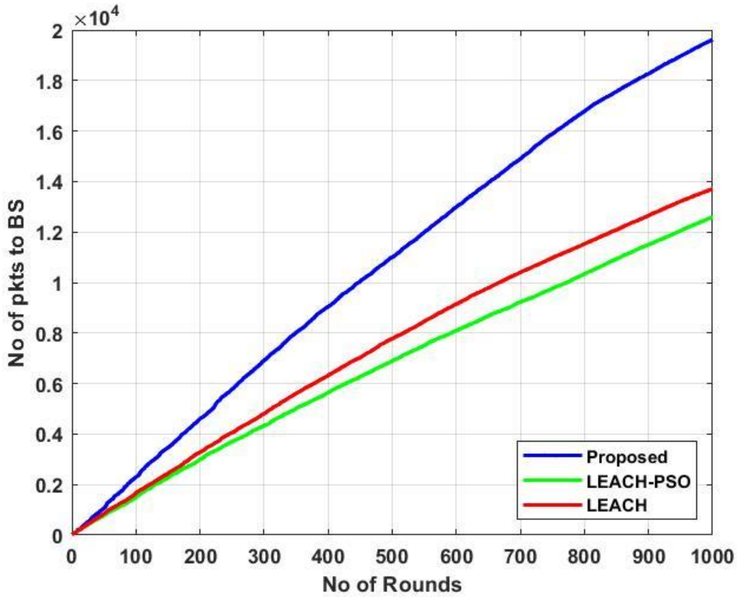

Figure 5: Number of packets to a base station

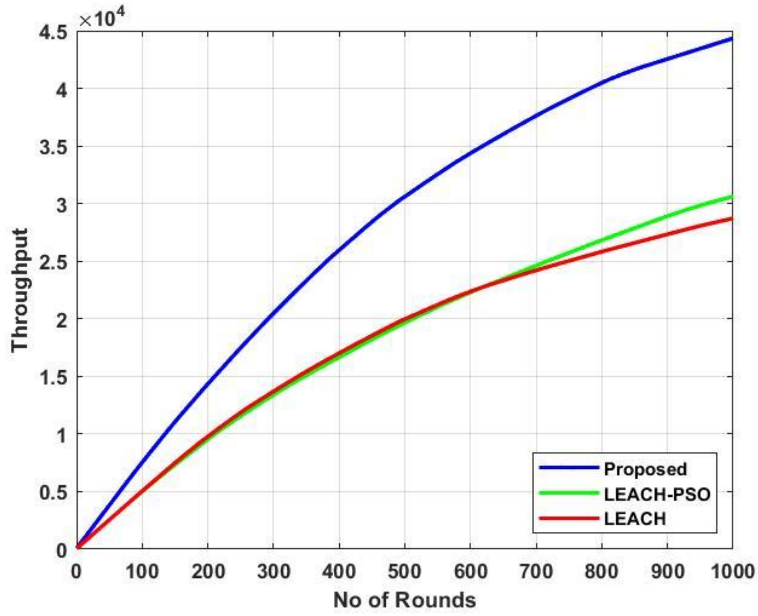

Figure 6: Throughput

The proposed approach is validated by considering the average residual energy. The proposed method is compared to established methods like LEACH-PSO and LEACH. The average residual energy is validated by using the number of rounds. During 100 rounds, the proposed method has a 38 average residual energy. Similarly, in the various rounds of 200 and 300, the proposed method has a 15 and 14 average residual energy. The conventional techniques of LEACH protocol have a 24 and 25 number of average residual energy during 100 rounds. When compared with the conventional techniques, the proposed approach achieved high average residual energy. The number of packets is used to validate the suggested method. The suggested methodology is compared to more established methods like LEACH-PSO and LEACH. The number of sending packets is validated by using the number of rounds. During 200 rounds, the proposed method has a $0.5 * 10^4$ number of packets sent in the UWSNs. Similarly, for the various rounds of 300 and 400, the proposed method has a $0.7 * 10^4$ and $0.6 * 10^4$ number of sending packets in the UWSNs. The conventional techniques of LEACH protocol have a $0.3 * 10^4$ and $0.2 * 10^4$ number of sending packets during 200 rounds. When compared with the conventional techniques, the proposed approach achieved a high count of sending packets.The proposed approach is validated by considering the throughput, which is validated by using the number of rounds. During 200 rounds, the proposed method has a $1.5 * 10^4$ in the UWSNs. Similarly, in the various rounds of 300 and 400, the proposed method has a 2*10^4 and $2.6 * 10^4$ throughput in the UWSNs. The conventional techniques of LEACH protocol have a $0.4 * 10^4$ and $0.3 * 10^4$ throughput during 100 rounds. When compared with the conventional techniques, the proposed approach achieved high throughput parameters.

5. Conclusion

In order to increase the network lifetime in UWSNs, this research designed an ESBLEACH for lowering the amount of energy spent. Here, solar energy has been utilized for energy harvesting with external powersources to the sensor nodes. This solar-based external power scheme has been utilized for empowering the network lifetime of UWSNs. The main objective of the proposed approach has been to select CHs in addition efficient routes to a terminus. The proposedapproach integrates two main procedures, namely the COA based leach protocol for multi hop routing. The COA approach choose CHs in addition systematizes clusters related on dissimilarconstraints likeabsorption loss, spreading loss, propagation sound, ambient noise, signal-to-noise ratio, transmission loss, and propagation delay. Performance metrics include Network lifespan, total energy usage, and other metrics have been used to evaluate the proposed technique's performance once it has been implemented in MATLAB. The proposed method has been compared to traditional methods like the LEACH protocol and the LEACH protocol with PSO.

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