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ENERGY AWARE MULTILEVEL CLUSTERING SCHEME WITH WAKE-UP SLEEP ALGORITHM IN UNDERWATER WIRELESS SENSOR NETWORKS

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ABSTRACT

For a wide range of reasons, researchers are interested in underwater wireless sensor networks (UWSNs). These include water quality and environment monitoring, disaster and earthquake prediction, surveillance by the military, and underwater navigation. Nevertheless, there are a lot of drawbacks and difficulties that come with the aquatic medium, including a high multipath delay, high levels of interference and noise, a harsh atmosphere, poor bandwidth, and short battery life for the sensor nodes. Yet, there are several obstacles to the successful deployment of underwater wireless sensor networks. The issue of sensor node energy depletion is the main cause of concern in the underwater sensor network. These problems require the use of good research methodologies and strategies to solve them. In this study, an Energy-Aware Multilevel Clustering with Wake-up Sleep Algorithm is developed to prolong the lifespan of the underwater wireless sensor network. The oceanic network region is thought to be a series of multi-level, 3D cylinders. High water pressure directed at the sea floor creates communication problems that are resolved by many layers of differing heights. The effectiveness of the suggested method is demonstrated by simulations, which demonstrate that it performs better in terms of an extended network lifespan, average residual energy, and many more factors. In comparison to the results of the simulation with current ones, the network lifespan has significantly increased.

Keywords: underwater wireless sensor networks (UWWSN), energy-aware multilevel clustering scheme (EAMCS), wake-up sleep algorithm (WSA).

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1. INTRODUCTION

Over 71 percent of the Earth's surface is covered with water, while the seas contain 96.5 percent of the planet's total water. Terrestrial Wireless Sensor Networks (TWSN) and UWSNs are very distinct from each other [1-3]. In TWSN, radio transmission is the primary means of communication. UWSN focuses on acoustic communication since radio communication is not effective. The sensor nodes are all placed in an unstructured manner in UWWSNs. Resource availability for sensor nodes, such as battery life, bandwidth, memory, etc., is extremely constrained [4-6]. The battery life of nodes determines how long wireless sensor networks can last since nodes use energy throughout every operation and eventually run out of power. It is unable to recharge or replace the battery of nodes due to the harsh/remote application region [7-9]. This issue of energy efficiency is the subject of a lot of research. Data transfer between nodes is the major cause of energy usage. Each cluster chooses a head node to serve as the data control point and be in charge of local data fusion. UWWSNs networks consist of several sensor nodes that are close to or inside the application area. Sensor nodes with limited battery capacity can communicate wirelessly, process data, and sense their environment [10-13]. To do the operation quickly and deliver reliable information, sensor nodes cooperate. Sensing the application area, sensor nodes communicate data via a single hop or several hops to a base station that may be inside or outside the application region. The user may have remote access to the data that has been collected. The performance of clustering algorithms depends on the selection of the cluster head [14]. There are emerging UWSNs that include automation also. We must schedule to lengthen the life of the WSN node [15-18]. Scheduling is nothing more than a mechanism that permits certain nodes to operate in active mode while the remainder nodes operate in passive mode, but we must be careful to avoid having this affect the system's performance [18-21].

2. EXISTING METHODS

A. Balanced Energy Efficient Circular Routing (BEEC)

The Balanced Energy Efficient Circular BEEC routing system for UWSN was suggested by Ahmed Raza Hameed *et al.* The primary objective of BEEC is energy efficiency. The network field is thought of as ten circular areas, with eight sectors forming each circle [22]. Each of the two movable sinks is positioned such that it serves five circular areas.

Each node receives the same quantity of energy in the beginning. Acoustic communication between nodes is used to transmit data. Sinks come with both acoustic and radio modems. Mobile sinks go through the designated areas and gather data from the nodes. As a mobile washbasin approaches a node, it must deliver a "hello" message.

The positions of the nodes are not given priority, but the sinks migrate according to a set pattern [23-25].

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B. Energy Efficient Grid Routing Based on 3D Cubes (EGRC)

A trustworthy data transmission system for monitoring complex environments (EGRCs) in UWSN was put out by Kun Wang *et al*. It treats the network as a set of 3D cubes. Moreover, each is split up into small cubes (SCs). The base station has a continuous power supply, and positioning algorithms are used to determine where it is. It has both an acoustic and a radio modem. The region is divided into top and bottom surfaces [26]. The upper surface of the water is referred to, and the bottom is the seafloor. The base station is situated in the region being monitored on the surface. The cluster head node will be chosen by each small cube, and all other nodes will send data to that cluster head. The residual is used to choose the cluster. The residual energy is taken into account while choosing the cluster. This makes use of the same energy consumption concept as the Low Energy Adaptive Clustering Hierarchy LEACH. The technique reduces energy consumption and end-to-end delays, but the cluster head's early energy depletion compromises system performance [27-30].

C. Multilayer Clustering-Based Butterfly Optimization Routing (MCBOR)

The MCBOR algorithm uses the perceptions of butterflies to send data packets to the target location without any loss. PDR will be raised and transmission loss will be decreased with the suggested work. By comparing the suggested MCBOR's performance to cutting-edge techniques, its performance is assessed. The suggested MCBOR provides a packet delivery ratio of 0.98%, an end-to-end latency of 6.3 s, and a residual energy of 0.47 J based on the evaluation report. Hence, it is demonstrated that MCBOR is more effective in PDR and lowers transmission loss only.

3. ANTICIPATED SYSTEM

A. Clustering and Routing Phase

The network model taken into account by the suggested Energy-Aware Multi-Level Clustering Method with Wakeup Sleep Algorithm (EAMC with WSA) for Underwater Wireless Sensor Networks is described in this section. The cylinder is used to define the network area. The transmission range of the sensor's sensor is represented by r. The cylinder is further split into sectors. The network deployment region's maximum depth is the same as the cylinder's height. Each cylinder has multiple plates or levels. Each structure's height varies depending on the transmission loss caused by water pressure, which decreases as depth increases. The suggested method uses a Block as a primary partition since clusters are built at each Block [31].

Cluster Head (CH) nodes are chosen from each Block. The beacon message broadcasting technique provides the basis for CH selection. By distributing its residual energy (RE) and distance from the Block center to all of its neighbouring nodes, a node that has more RE than the energy threshold can participate in the CH election. The energy threshold is defined as the average block energy [32-35].

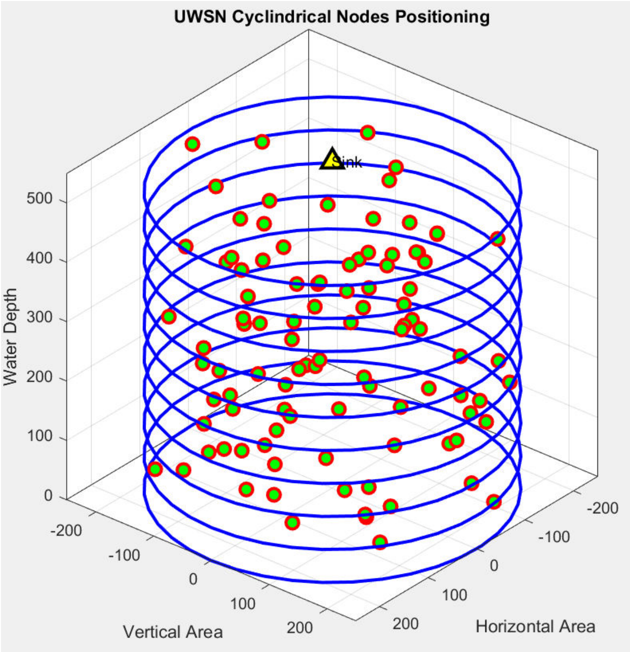

Figure-1. Nodes positioning in UWWSN.

The node with the highest residual energy and the closest proximity to the center is chosen as the cluster head. The cluster members' communication range with CH is kept to a minimum by choosing nodes that are close to the block center. Once chosen, the CH sends the selected message to each of its neighbours. The evel of CH, residual energy, and location coordinates are all included in the chosen message. A regular node replies to its CH with a joining message that includes the node ID when it gets the elected message. If more than one CH sends an elected message to a node, the node will select the CH with the highest Fitness score (F).

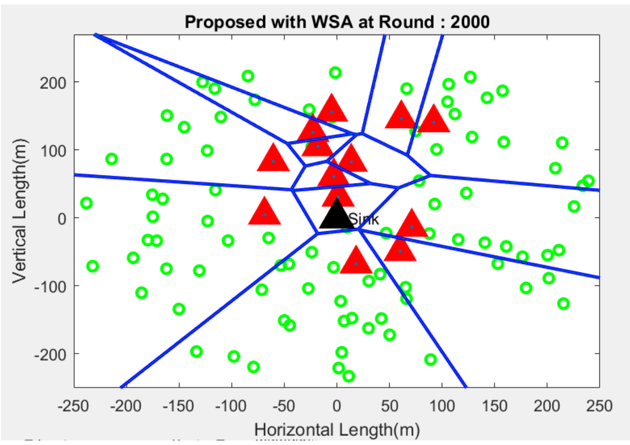

Figure-2. EAMLCS with WSA at Round 2000.

Based on each node's distance, remaining energy, and level, an independent estimate of the fitness value of

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CH is made. A CH with a short distance and a high residual energy value is more suited.

There is an equal distribution of nodes among the clusters as a result of the fitness-based CH selection process. Each member of the cluster changes its transmission range according to the distance to its CH after entering the cluster. It significantly lowers the node's transmission cost.

Vertical acoustic data transmission has reduced transmission loss since it was shown to be more dependable and controllable by the UWSN research community. Vertical communication is the main emphasis of the suggested clustering approach. As a result, inter and intra-cluster communication occurs vertically and from the bottom up.

At each surface level, gateway nodes or sub-sinks are installed to gather data from the CHs of the corresponding blocks at all lower levels. The radio and acoustic modems on gateway nodes have a long transmission range and an endless or swappable power supply. A surface-level block's gateway node also serves as the block's cluster head.

Scheduling when to sleep and get up is a very effective technique that uses the least amount of energy possible from the network. Once the network has formed its clusters, each cluster begins using the process of sleep/wake scheduling. Only one in each cluster with the greatest remaining energy must remain active to conserve energy; the others will be kept on in sleep mode.

All of the cluster's nodes will be active at the start of this schedule to examine the residual energy. The goal of this research is to identify the active node in a cluster that has the largest residual energy. In a cluster, this active node will carry out the sensing duty. The cluster head will select the node that will do the sensing operation. The cluster head sends a message to instruct the chosen node to carry out its function as an active node. One of these nodes is also instructed to serve as the cluster head for the next period. The cluster head also notifies all of the other nodes to go to sleep using the SLEEP message.

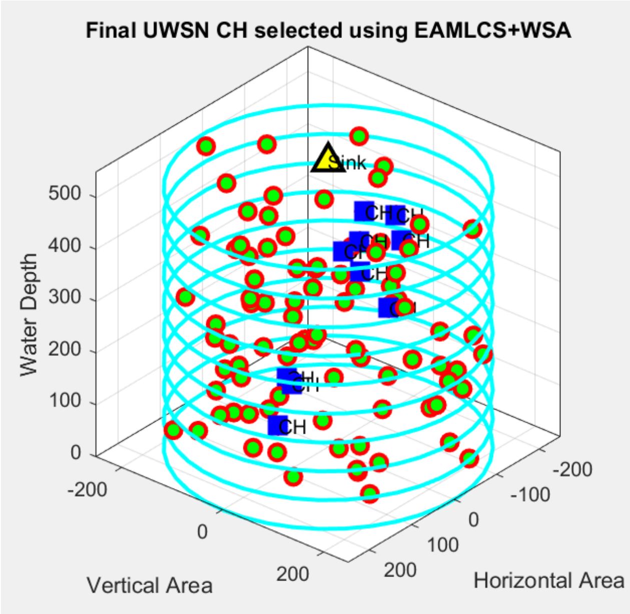

Figure-3. Final UWSN CH selected using EAMLCS with WSA.

4. RESULTS

The effectiveness of EAMC with WSA is assessed in comparison to EGRC, MCBOR, EAMC, and BEEC. The network lifespan, node residual energy, throughput, and PDR are the parameters chosen for comparison. Extensive simulations are done using the MATLAB software.

In the 500-meter-deep, 250-meter-diameter cylindrical underwater region, 100 nodes are placed in total. Table-1 contains a list of the simulation's parameters.

Table-1. Simulation Parameters.

Simulation Parameters	Values
Number of Nodes	100
Radius of Cylinder	250 m
Number of Rounds	2000
Depth of Cylinder	500 m
Number of Packets	6400 bits

A. Network Lifetime with Number of Rounds

The Network lifespan is calculated here for various Rounds. The outcomes are evaluated in comparison to the MCBOR, BEEC, and EGRC algorithms. As a result of the simulation, it is clear that the suggested method performs better than the other algorithms under comparison. The comparison of the network lifespan with rounds is shown.

Because of the mobility of the nodes, the BEEC algorithm suffers greatly from frequent route estimation and transmission overheads, which significantly shorten the lifetime of the nodes. The node's intra-cluster transmission distance results from EGRC's failure to take the node's location in the CH selection into account. As a

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result, the nodes have severe energy depletion when transferring data over longer distances. CHs result in sinkhole issues and early energy depletion issues. The end-to-end latency of data transmission is primarily addressed by MCBOR, but the load distribution among CHs is not taken into account. As a result of the greater load and the excessive density of the network, CH energy drained quickly. They distribute the nodes across CHs by using the fitness value of CH nodes and the suggested algorithm. The suggested algorithm increases the longevity of the network. Compared to the other four algorithms, it goes on for a greater number of rounds.

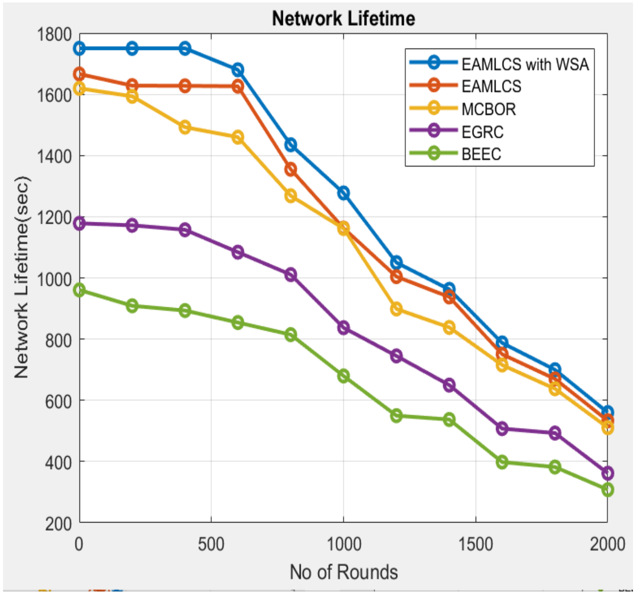

Figure-4. Network Lifetime vs. No of Rounds.

B. Throughput with Number of Rounds

The amount of packets per second that are received at the destination is measured by the end-to-end network throughput. It is taken into account in this instance as an outside indicator of a protocol's efficacy. For Example, if it takes 1 second for a packet of 100 bytes to go from Computer A to Computer B, the throughput between the two machines is 800bps. Notice that 8 bits make up one byte. As a result, 100 bytes are equal to 800 bits, yielding a throughput estimate of 800 bits per second. As compared to the rest; the suggested method performs well in throughput.

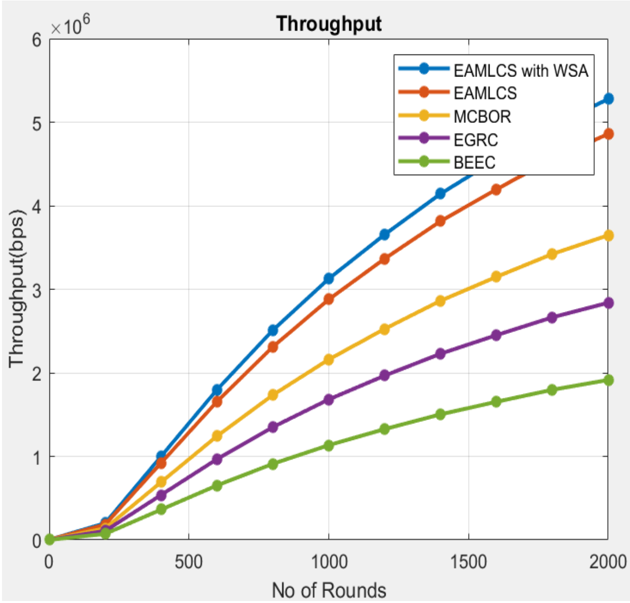

Figure-5. Throughput vs. No of Rounds

C. Energy Metrics with Number of Rounds

By adding the energy lost while the sensor node was in each condition, it is possible to determine the sensor node's remaining energy. The nodes in the BEEC experienced substantial energy depletion as a result of frequent route estimation and greater transmission overheads. Furthermore, losing additional energy during intra-cluster transmission, EGRC loses its nodes in just fewer rounds. MCBOR performs better than BEEC and EGRC, although CH nodes experience challenges with irregular energy consumption as a result of poor load distribution. The suggested approach achieves higher threshold, indicating that it is superior in terms of load distribution and network performance.

Residual energy for network size 100 is examined in comparison to other techniques. The suggested EAMC with the WSA algorithm demonstrates the obvious progressive energy consumption. This is so that another node with more leftover energy can take over as the CH whenever the CH reaches a certain value. The suggested technique also effectively lowers the cost of transmission between and within clusters. As a result, the network's nodes' energy consumption is dispersed equitably. The average residual energy of the network is lower across all algorithms as the number of nodes rises.

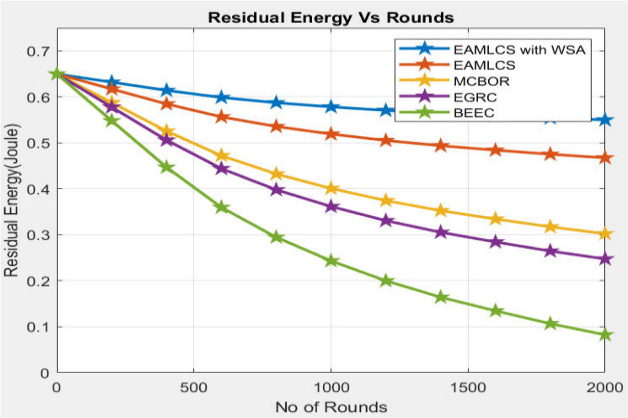

Figure-6. Residual Energy vs. No of Rounds

5. CONCLUSIONS

One of the problems that affects UWSN performance in terms of network lifespan is early energy depletion. That can be the result of network nodes' unequal energy usage. The goal of EAMC with WSA is to make the network last longer. Switching the CH whenever its residual energy exceeds the threshold level, should offer a new local remedy. To ensure that the communication is unaffected by water pressure, the cylinder's level is set such that it is higher at the surface level and lower as it approaches the bottom. The network should be greatly improved by the changes to the network structure.

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