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Growth Ring Style Uneven Node Depth-Adjustment Self-Deployment Optimization Algorithm (GRSUNDSOA) Towards Energy Efficient Clustering Algorithm In Underwater Sensor Network

A.Amudeshwaran[1] , Dr.G.Baskar[2]

[1]Research Scholar, Department of Computer Science, KSG College of arts and Science Coimbatore, Tamilnadu, India.

[2]M.sc., M.Phil., PhD., Assistant Professor, Department of Computer Science, KSG College of arts and Science Coimbatore, Tamilnadu, India.

Abstract

Due to limited energy sources of the underwater sensor nodes, effective routing algorithm for energy efficiency has been considered as importance of the particular research. Many traditional routing model has been implemented for energy balancing on the acoustic network, despite of many advantage of the routing technique, still many challenge has been continuing in terms of coverage and connectivity. In order to tackle those challenges, a new routing protocol named as uneven node depth adjustment self deployment along Energy Efficient Clustering has been proposed to Underwater Acoustic Sensor Network based on metaheuristic techniques. In this methodology, autonomous depth-adjustment deployments for sensors achieve maximized coverage, minimized energy consumption and guaranteed connectivity to sink Nodes by employing a Growth ring style strategy on uneven node depth-adjustment self-deployment optimization algorithm (GRSUNDS Ln O). In this common nodes are organized as tree structures and the depths for all nodes are computed based on the global maximizing coverage utilization and energy balance iteratively. Sensor Node transmits the sensed information as packets using cluster heads to surface sink via relay node selection for path prediction using Sea Lion Optimization Technique. On computation, energy efficient nodes have been classified. On simulation analysis on Matlab R2018b, proposed model has been compared with existing scheme to demonstrate the effectiveness of the proposed scheme especially in void cancellation in order to prolong life time of node and to provide good communication and networking performances in terms of path length , Energy consumption efficiency, coverage and Average Node degree. Finally it has been proved that proposed model attains better benefits on both coverage and connectivity of the clustered node to produce the energy consumption in underwater environment

Keywords: Underwater Acoustic Wireless Sensor Network, Energy Efficient, Clustering, Seo Lion Optimization, Void Cancellation, Coverage, Communication

1. Introduction

Underwater Acoustic Wireless Sensor Network has made great progress and attracted more and more researcher's attention due to growth of the wide application demands, such as the environmental monitoring, pollution control, disaster forecast and military activities. In underwater environments, the electromagnetic wave signal will be affected by the strong attenuation caused by the propagation medium [1]. Fortunately, by using the acoustic wave, we can achieve a reliable data transmission over a long distance at a relative low frequency [2]. However, due to the high complexity of the underwater environment and the slow propagation speed of the underwater acoustic wave, there are still lots of problems about the quality of the communication need to be solved, such as limited frequency bandwidth, long communication delay, and so on.

Among managing the lifetime of the batteries, deployment of the node is a crucial issue in the network topology due to medium of its deployment as it is acoustic and large volume of monitored area. Further deploying nodes as static many become infeasible in inaccessible regions. Moreover movement assisted deployment is another mode of deployment, in these sensors are embedded in mobile platforms such as autonomous underwater vehicles (sensor) which is driven by the mobile devices which is considered as costly and these type of sensor are very large . A mobile device moves the sensors to their final locations after they are dropped randomly onto the water surface. However, in practice, the energy supply of the underwater sensor nodes is limited, and it is difficult to charge or replace it, which requires large amount of planning and cost.

To improve the energy utilization of the Underwater Wireless Sensor Network, energy efficient clustering algorithm to cancel the void in the network has been proposed on utilizing SEO Lion optimization and void cancellation techniques. Nodes of the particular network are adopted to growth ring style is assisted by sink nodes which is considered as relay nodes [3]. It is considered as most efficient way to realize the energy optimization for the multi-hop sensor network on the uneven node deployment condition. In addition, it keeps good communication performance and achieves the goal of a long life time. Further adaptive holding time is used on basis of channel conditions and link quality by which reliability of the network to minimize the latency and packet collisions and to improve the network lifespan.

The rest of the paper is organized as follows In Section 2; the related work about the clustering algorithm for the underwater acoustic sensor networks has been presented. The related models mentioned in this paper. In Section 3, we present the proposed uneven node depth adjusted self development through Energy efficient clustering scheme for the multi-hop underwater sensor network. The simulation results of the proposed model are presented in Section 4. Finally, a conclusion of the work is provided in Section 5.

2. Related work

In this section, various existing model enumerating void cancellation self adjusted energy efficient routing techniques on underwater wireless sensor network has analyzed on basis of connectivity and coverage aspects towards efficient data communication between nodes in detail as follows

2.1 **A Machine-Learning-Based Adaptive Routing Protocol for Energy-Efficient and Lifetime-Extended UWSN**

In this work, underwater sensor network (UWSN) has been examined in detail in terms of high latency, low bandwidth, and high energy consumption. It is challenging to build networking protocols for UWSNs. To addressing the routing issue in UWSNs, an adaptive, energy-efficient, and lifetime-aware routing protocol based on reinforcement learning, QELAR has analysed to be better alternative [6]. The protocol assumes generic MAC protocols and aims at prolonging the lifetime of networks by making residual energy of sensor nodes more evenly distributed. The residual energy of each node as well as the energy distribution among a group of nodes is factored in throughout the routing process to calculate the reward function, which aids in selecting the adequate forwarders for packets.

2.2. Localization techniques for underwater acoustic sensor networks

In this work, underwater acoustic sensor networking has been enabled for a wide range of applications including naval surveillance, oil platform monitoring, earthquake and tsunami forewarning, climate and ocean observation, and water pollution tracking. Underwater sensor nodes have been modeled with sensing and communication capabilities in order to form the underwater acoustic sensor network. Localizing of the underwater sensor nodes is one of the mandatory tasks for UWSNs as location information can be used in providing Meta data, routing, and node monitoring.

3. Proposed model

In this section, a new frontier approach named as growth ring style uneven node depth adjusted self deployment defined energy efficient clustering algorithm based on the Sea lion Optimization (GRSUNDSLnO) has been developed to enhance the void cancellation in deployment condition along prolonging life time of network of interacting nodes on specific topology has been designed using various energy related constraints as follows

3.1. Network Model

In this work, underwater sensor nodes deployed to monitor the underwater environment and the activities of the marine life[5]. Network deployed with n sensor including base station and AUVs which is randomly deployed. Each sensor is associated with a sphere sensing range.[6] A base station (BS) is set up above the sea level or in a neritic zone to collect the transmitted messages**.** The AUV is utilized to assist the communication between each underwater sensor node and the sink node**.** Sensor node varies on four modes such as active, asleep, malfunctioned, and dead[7].

Only active sensors serve to detect targets and consume their battery power. To save power, sensors that are not active can be turned off, said to sleep. In practice, sensors may be temporarily malfunctioned, and could be recovered later. A sensor may be dead due to battery power depletion, or get lost due to external factors (e.g., flushed by ocean currents) . Due to different sensor modes, the number and IDs of active sensors vary at different times. According to the UASN, configuration, the proposed scheme decides a sleep schedule [8]. Sleep schedule is decided for using the updated information of survival sensors.

Node Deployment – Growth Ring Style Self Deployment:

In this construction, incremental broadcast radius calculation is utilized to determine the Growing Ring (GR)s and construct the connective tree structure. It means that the radial distance between the GRs increases with its distance to sink node Growth ring style strategy has been proposed to uneven node depth-adjustment self-deployment optimization algorithm. In this common nodes are organized as tree structures and the depths for all nodes are computed based on the global maximizing coverage utilization and energy balance iteratively. Further it constructed as the entire nodes dive to the new positions once according to the computed depths and 3D connected UWSN with uneven distribution nodes and balanced energy

3.2.Clustering of Underwater Acoustic Wireless Sensor Network

In this section, Leach [9] based Clustering model is applied to arrange the sensor nodes in cluster. Further it identifies the cluster head on basis of residual energy of the node and number of neighbor nodes on basis of its driving depth on basis of forward subtree root nodes (FSRN). Cluster head selection is carried out to ensure uniform distribution of energy among the sensors measured with respect to offset distance, horizontal distance and expect distance. It is to consequently increasing the lifespan and coverage of a sensor network. After selection of the cluster head, the cluster head periodically collect, aggregate, and forward data to the BS using the minimum energy (cost) routing.

The nodes of UWSNs constructed by this deployment method are non-uniformly distributed ring by ring. Growth Ring strategy searches the global optimal dive position based on the basic nodes for depth calculation rather than the local optimal dive position. Self Deployed node for cluster and cluster on basis of position and energy constraints to form routing table for reliable data communication for void cancellation.

Strategy

Uneven Node Clustering ()
    Partition N_s network Structure into Layers $L_1, L_2 \ldots L_n$
        Compute h_i is depth of node on each layer
            Estimate r_i of senor nodes N_i
            Cluster Node N_I with CH on condition $h_i < r_i$

Sink Node in the UWSN can always collect the data of each CH node correctly as long as the Sink Node can be close enough to the CH node due to the powerful energy supply of Sink. The optimal design of Sink data collection path among the CH nodes carried out using Seo Lion Optimization which is described in detail in various strategies of uneven node management on basis of deployment conditions on coverage depth. Sensor node consumes most of its power on communication, especially when it needs to transmit its data to the BS which is located far away from the UWSN is done on basis of ring style to optimal drive candidate selection. Figure 1 represents the multihop UWSN cluster structure of the proposed work.

Mobile Sink is waiting to receive packet P
If (Sink Energy ≥ s Eth)
Forward packet to Base Station BS
Else
Send data to nearest sink

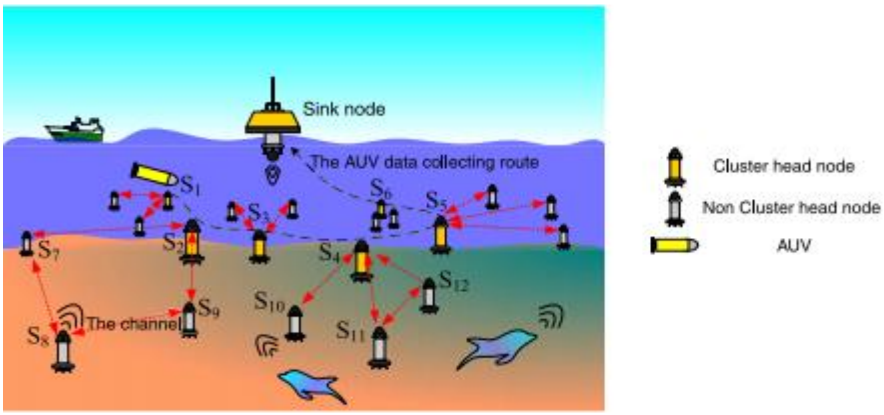

Figure 1: Cluster Structure of UASN

Employment of cluster head and sink effectively reduces the energy consumption and increase the data communication speed on uniform distribution of nodes to the network[10]. In the clustering algorithm, each underwater sensor node firstly counts the number of neighboring nodes within d transmitting hops, which is called the potential number of nCH nodes based on d-hop for each underwater sensor node. Then the node with maximum potential number of nCH nodes based on d-hop is selected as the CH node in each locality. It means that if an underwater sensor node can connect with more neighboring nodes within its effective communication range, it is more likely to become the CH node.

3.3.Seo Lion Optimization

In this part, Seo Lion optimization is carried out on the uneven node has been decided on basis of various factors to commit node for data communication. Especially connectivity and coverage considered as primary factor. In acoustic network, trace file collects ambient noise, water temperature, Phase velocity, Wave Number, residual energy of the node, queue length, energy density of neighbor nodes, motion of the sensor nodes, distance between the sink node and sensor node and data traffic. Data reliable routing is carried on void cancellation strategies on utilization of the routing table for path selection to surface sink to data transfer.

Sea Lion Optimization Technique has been employed for path selection and relay node selection to reach the surface sink. Mobility of the node on change of horizontal position due to waves and water current will be effectively controlled using optimal path to the sink node. Growth sytle algorithm estimates the effective dynamic deployment conditions on the processing of the FSRN model. Figure 2 provide the architecture diagram of the proposed work on uneven node clustering on the dynamic deployment condition

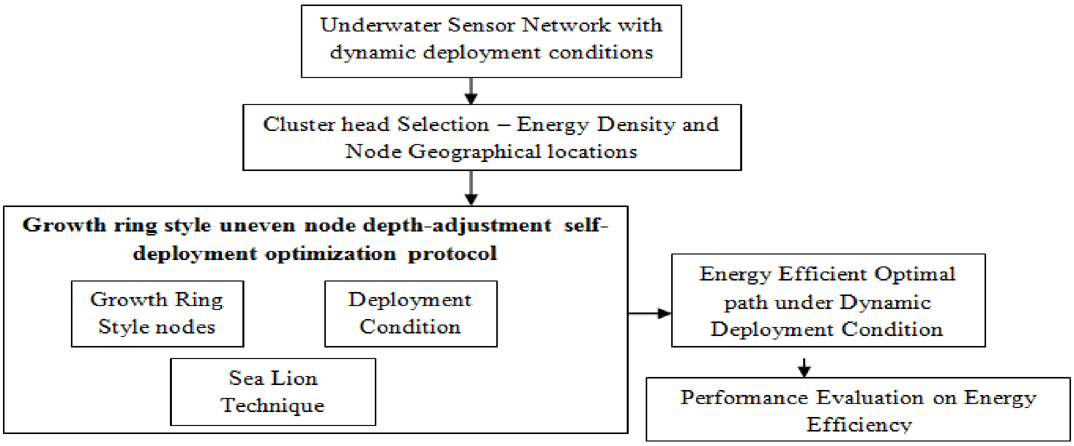

Figure 2: Architecture Diagram of proposed methodology

In this architecture, SEO optimization reduces the average length of data transmission to the sink node on computing the optimal path on basis of the projection and probability of the ring style on the node degree.

Algorithm 1: Ground ring style based Uneven Node depth Adjustment self deployment Sea Lion optimization Algorithm (GRSUNDSLnO)

Input: Uneven node deployment of network

Output: Depth Adjusted Energy Efficient Node clustering

Process:

Compute Matrix n*m for Trace File of nodes x, y and z

$$C = \begin{pmatrix} \operatorname{cov}(x,x) & \operatorname{cov}(x,y) & \operatorname{cov}(x,z) \\ \operatorname{cov}(y,x) & \operatorname{cov}(y,y) & \operatorname{cov}(y,z) \\ \operatorname{cov}(z,x) & \operatorname{cov}(z,y) & \operatorname{cov}(z,z) \end{pmatrix}$$

Adjust original value of the single factor of node with mean value

Deployment Condition

$$D= = \sum_{k=0}^{n} \binom{n}{k} x^k Ga^{n-k}$$

Where Ga is growing Style

$$X' = X - \bar{X}$$

Compute Euclidean Distance for Node X and Node Y on Multiple Factor

$$Coverage(X,Y) = \frac{\sum_{i=1}^{n}(X_i - \bar{X})(Y_i - \bar{Y})}{(n-1)}$$

Determine Coverage and Perception model(X,Y)

Perception model Ce=$\lambda_{xde}\sqrt{x^2 + y^2}$

Connectivityr is the factor of node with same direction of sink node

Where λx_d is the Connectivity value of the Coverage(X,Y)

Perception Value Corresponds to growing variance of the node of each sink nodes

$$\text{Node Degree Nd} = \sum_{n=1}^{\infty}\left(a_n \cos\frac{n\pi x}{L} + b_n \sin\frac{n\pi x}{L}\right)$$

Extract Top 10 perception values of the Connectivity value C**e**

Seo Lion Optimization analysis computes effective node for deployment for effective data commuication on strong connectivity and coverage. Moreover, due to the changes of the residual energy and the distance to the sink node for each sensor node, the selection of the node will not change mobility of the underwater sensor node caused by the ocean currents. In order to properly simulate the ocean currents in actual situation, Void cancellation technique has been employed to increase the efficiency of the model.

On the broadcasting phase, the sink node will broadcast a short package to each underwater sensor node, which contains the transmitting time on basis of average length and energy consumption measures. Further energy efficiency, residual energy and transmission distance to the sink node of each underwater sensor network. Underwater sensor node can continuously receive and store the broadcast information from its neighboring nodes under various dynamic deployment condition, including their actual potential number of CH nodes based on hop values, ID numbers and the initial transmitting times of the information. Hence, the priority of the underwater sensor node being selected as the CH node is negatively correlated with Ti .

The source node (Ni) measures the information from the aquatic environments. Whenever a source node has data packets to send at the surface sinks (Si) then it scans the routing table. Routing table is to check its concerned CH (CH i), for which the Cube ID(Ni) and Cube ID (CH i) must be identical
If (Cube ID matches with Chi)

Then (the source node forwards the data packet)
Elseif(The source node didn't find its concerned CH,
Then (it will choose the nearest CH from the routing table.)

Anchor nodes are used as CHs to collect the sensed data packets from underwater source nodes. Henceforth, CHs have data packets to send at the surface sinks, for which they scan the routing table B(CH i) . Routing table B(CH i) is used to find any nearest surface sink (Si). CHs of lower cubes will identify the neighboring CHs as a next-hop that has a lower depth level than them. Hence, in this way, the data packets will successfully reach the destination. The transmission radius of the CH is tuned with the cluster width to cover the maximum volume of the cluster and can reach the neighboring CH.

The beaconing procedure is used to share the local information of the nodes (surface sinks and cluster heads) with neighboring CHs and ordinary source nodes. By which source nodes can decide a route towards their designated CH, while CH can get the reachability information towards the surface sinks with the help of neighboring CHs. After the establishment of the routing path through a random beaconing procedure, the source node starts sending the sensed data to its respective CH. Hence energy optimization mechanism for the underwater sensor node has been employed using SEO to implement a unified control of each underwater sensor node. On one hand, the underwater sensor node will maintain a large effective communication and Coverage range when its residual energy is sufficient.

Void Detection

Due to dynamic nature of water waves, the nodes are prone to move in a random direction. To identify the void node, 2D Random Walk mobility model with a speed of 1-3 m/s has been employed to identify the node mobility. According to this, nodes can move horizontally in a 2D manner. While vertical movements of the nodes are less significant, so it can be ignored. In this mobility,

- If a node moves from its current cluster, then there will be two possibilities either this node enters the neighboring cluster or it exists from the network region. The node will check its current position after time Tm.
- If a node is entering the neighboring cluster then it is still inside the network space and performs its operations. If a node exists from the network region then it becomes a void node. So, whenever a node does not find its potential CH, it will broadcast a search-neighboring-CH message to all nearby nodes in order to save the data from loss.

Void Node Prevention

Void Node prevention is carried out in following ways

- If a node moves away from the network and does not find any CH in its vicinity, it disseminates a search neighboring CH message to inform the neighbors. In the case, this node does not have any neighbor node or the neighbor node itself is a void node, then the void node discards all the data packets as potential forwarding nodes are not available for collecting the data packets.

- If the void node has neighbors that are connected with the cluster, replies a search-neighboring-CH reply message along with its reachability information and designated CH
- If the void node receives multiple replies from the neighbor nodes, then it computes the depth-differences of the neighboring nodes. The void node selects the neighboring node having the
- lowest depth and close proximity to the surface sinks and send a route-request message for becoming an ad-hoc CH

On the other hand, the underwater sensor node will adaptively decrease its maximum effective communication range when its own residual energy is lower than a threshold and becomes less and less, which is helpful to prolong the life time of the underwater sensor nodes. The coverage range can be computed as follows

$$R=x = \frac{2R}{\pi}\tan(p)$$

Where p is E/E_o is percentage of residual energy

As a result, the number of neighboring nodes of each underwater sensor nodes may be changed in different clustering periods because of the change of the communication coverage and Connectivity of nodes

4. Simulation Results

Simulation of the proposed Self deployed uneven node clustering for energy efficient clustering in underwater acoustic sensor network is experimented and it is performed using Maltab simulator [11]. In this way, the uncertainty of the underwater acoustic communication environment due to dynamic deployment conditions [12] is simulated. In this deployment of the sensor node and its various configuration of the network on basis of growth style ring model with parameter setting has been provided in the table1

Table1: Network Configuration Setting

Parameter	Configuration Value
Network Coverage Area	$1000*1000m^2$
Number of underwater Acoustic Sensor Nodes	50
Initial Energy of Node	1000 Joules
Signal Frequency	12khz
Modulation mode	OFDM
Maximum Wind Speed	15m/s

Based on the above dynamic deployment configuration setting, network coverage results for proposed and state of art existing scheme has presented respectively in terms of number of node to sink [14] and energy utilization.

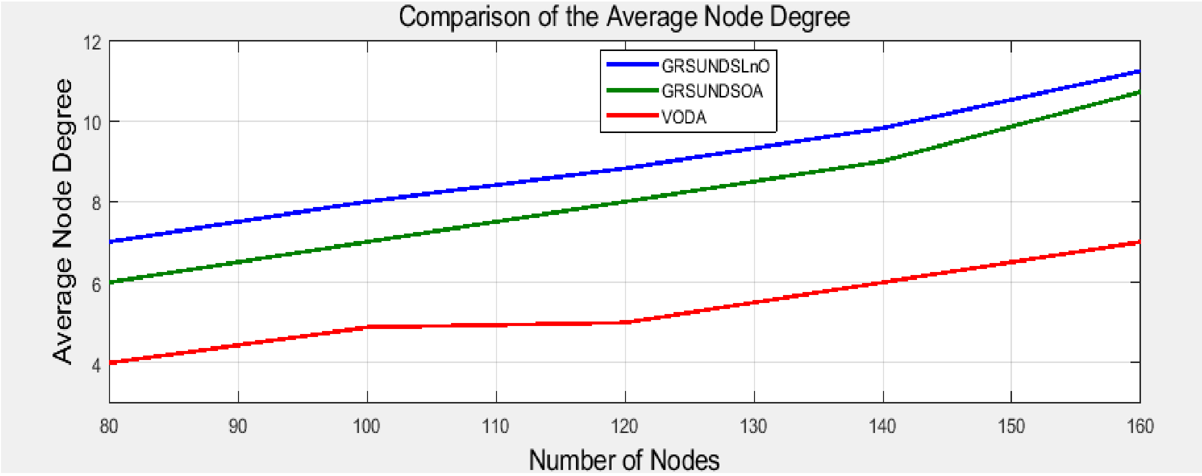

Figure 3: Performance Analysis of Average Node Degree

On analysis, the energy consumption of the underwater sensor nodes in proposed scheme produces energy efficiency than that in existing schemes on various coverage and void conditions in the network. Figure 3 represents the performance analysis of the average node degree of the UWSN towards changes of the surface sink on the cluster head selection to data transmission. The transmission radius of the CH is tuned with the cluster width to cover the maximum volume of the cluster and can reach the neighboring CH on basis of Euclidean distance between the sensor nodes with various energy levels .

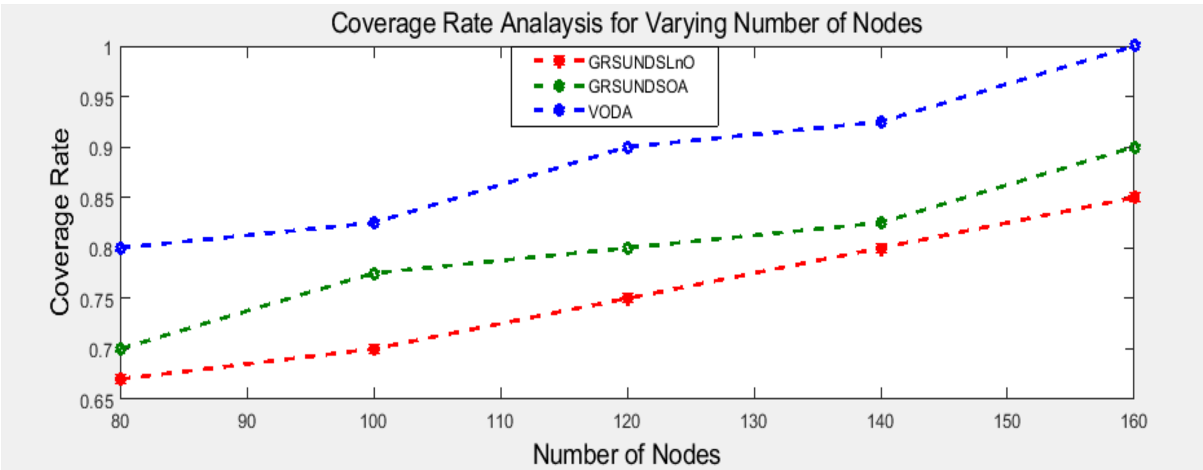

Figure 4: Performance Analysis Coverage Rate Analysis

Figure 4 provides the performance analysis of the coverage rate of the proposed scheme under various deployment conditions which can effectively avoid the void problem [13], the residual energy of the dynamic deployment uneven node is controlled by the proposed growth style model. It is gradually reduce the void effectively than the existing scheme. The

Average path length is defined as the ratio of the packet successfully received by all underwater sensor nodes to the total transmitting packets on the nodes.

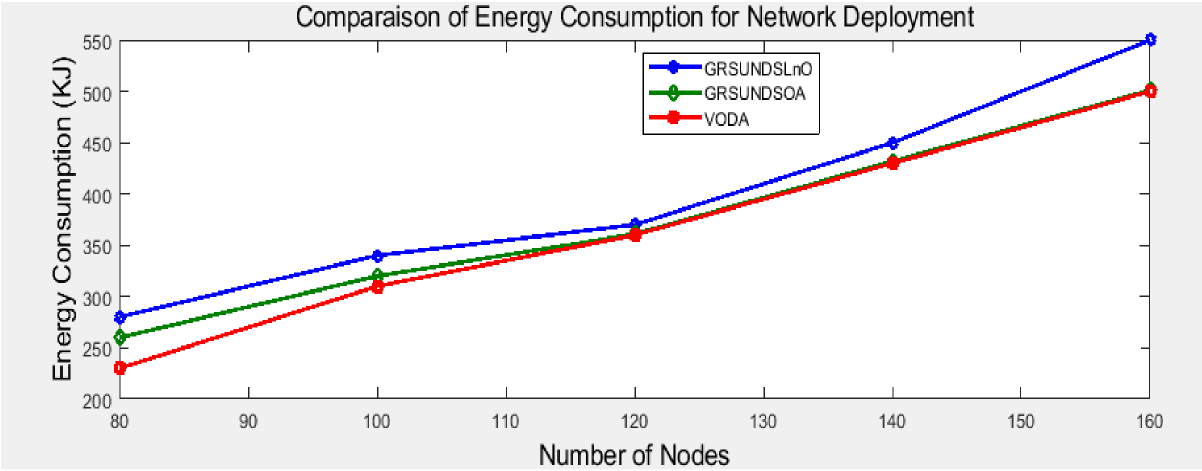

Figure 5: Performance Analysis of Energy Consumption

Figure 5represents the performance analysis of the energy consumption scheme of UWSN provides better performance as the sensors dive to their final positions adjusting their depths by themselves. Further it achieve maximized coverage, minimized energy consumption and guaranteed connectivity to sink Node. In this common nodes are organized as tree structures and the depths for all nodes are computed based on the global maximizing coverage utilization and energy balance iteratively

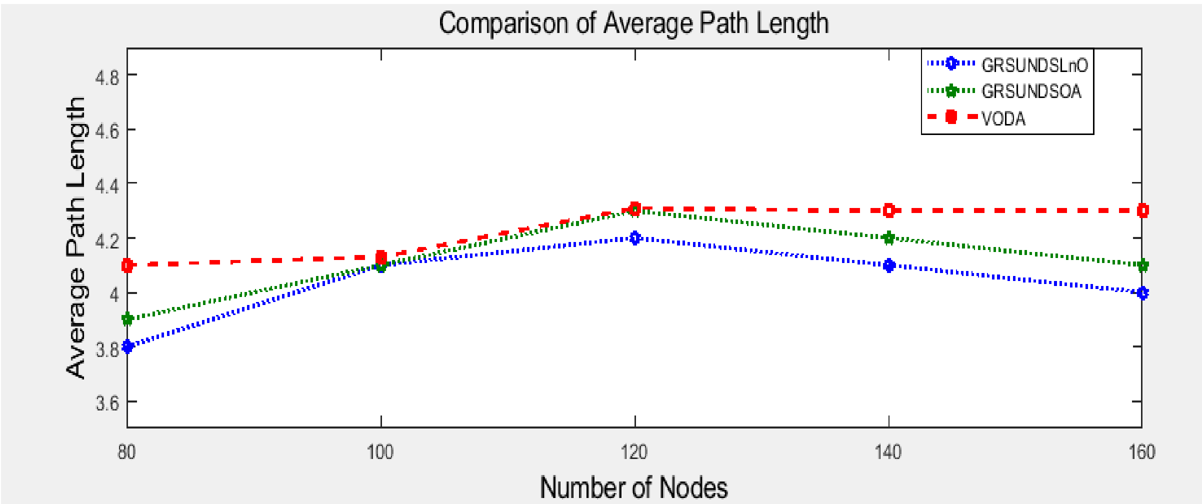

Figure 6: Performance Analysis of Average path Length

Figure 6represents the performance analysis of the average length of the dynamic deployment schemes of UWSN. In the proposed model, nodes dive to the new positions once according to the computed depths and 3D connected UWSN with uneven distribution nodes and balanced energy on employing growing ring style strategies for data transmission from sink to surface sink.

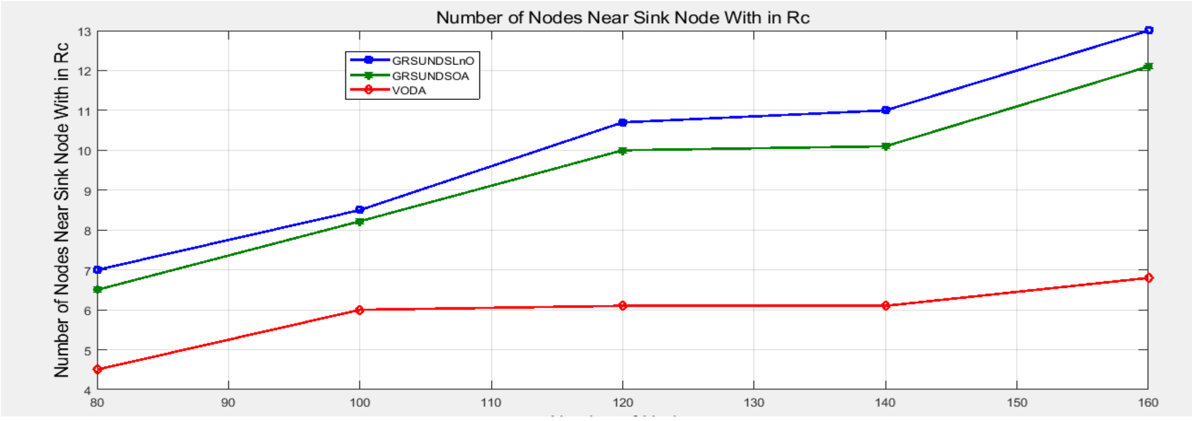

Figure 7: Performance Analysis of Traffic to the Sink Node

Table 2 describes the performance value of the void cancellation based energy efficient schemes for dynamic deployment conditions of the network. In addition the proposed model traffic to the sink node to be high as it sinks demonstrates the effectiveness in prolonging the network life time on capturing the data from various sink nodes. Finally, influence of the network coverage area for the proposed scheme has been analyzed with considering the mobility of the underwater sensor nodes to be effective.

Table 2: Performance Evaluation of the Deployment model of UWSN for void cancellation and Energy Efficiency

Technique	Node Degree	Coverage Rate	Average path Length	Number nodes to Sink Nodes	Energy Utilization
Growth ring style uneven node depth-adjustment self-deployment-Sea lion Optimization - Proposed	8	0.75	4.2 metre	9 nodes	350kiloJoules
Growth ring style uneven node depth-adjustment self-deployment optimization algorithm – Existing 1	7	0.7	4.4 metre	8 nodes	320 Kil0Joules
Verona-Based Optimized Depth Adjustment Deployment-Existing 2	5	0.65	4.6 metre	6 nodes	310kjoules

Moreover, with the increase of the number of the underwater sensor nodes, the network life time of the scheme would be in high level for dynamic void conditions and deployment conditions. Finally proposed scheme has proved that it can achieve the goal of effectively optimizing the system energy and void cancellation as well as providing a good communication performance through growth ring style structure.

Conclusion

Uneven Node depth adjusted self deployment **e**nergy efficient clustering algorithm for Underwater Sensor Network using growing ring style and Sea Lion optimization has been designed and simulated in this work. Proposed model utilizes the Sea Lion optimization for dynamic deployment condition of uneven node clustering to sink on effective processing of the node for data communication after the cluster head selection. The processed nodes on growth ring style strategies has been computed using void cancellation technique to limit the drain of battery life for data communication and to prolong the life of the network through effective selection of node to sink. As a consequence, the simulation results demonstrate that the system can effectively prolong the life time while achieving a high node degree and average node length. Finally proposed model has been analyzed on terms of connectivity and coverage on various aspects of the scheme.

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