Optimized Network lifetime and path loss of Underwater Wireless Sensor Network (UWSN) Using Multi-objective multi-verse optimization algorithm

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Abstract
In ocean scanning applications, such as ocean tracking, pollution sensor, ocean resource control, underwater system maintenance, etc, the underground wireless sensor networks (UWSNs) are commonly used. Due to the problems of underwater communication, underwater Wireless Sensor Networks (UWSN) have become a common research subject. One of the key purposes of an underwater network is to evaluate the improved path through the sensor nodes to the onshore station for the assignment of monitoring data. The transmission cycle requires energy from every node and energy is limited in UWSNs. The most demanding task in the underwater wireless sensor network, therefore, is energy efficiency. This paper focuses primarily on coping with the energy usage and network life.This paper proposes a Multi-Objective Multi-verse Optimization Algorithm (MOMVO) to optimize network life, path loss and minimize power consumption in UWNNs. In this paper, a comparative analysis of hierarchical routing protocols such as the stable election protocol (SEP), the Zonal-Stable Election Protocol (Z-SEP) and the LEACH-based Multi-Objective Multi-verse Optimization (MOMVO) is presented in a variety of performance metrics such as live nodes per round, base station packets (BS) per round, and dead nodes per round.

Keywords: Multi-objective multi-verse optimization, Network Lifetime, Underwater wireless sensor network, LEACH algorithm

I. Introduction:

The UWSN (Underwater Wireless Sensor) networks are also widely used as a marine monitoring system. can take three forms (sound, electromagnetic (EM), or optical waves). Each technique has benefits and disadvantages. The EM signals give low underwater efficiency, with a typical RF transmission power within only a few meters. Optical communication has also been explored for submarine sensor networks that use light waves. However, when the distances between sensor nodes are long, this method requires either high precision or high power. As a result, acoustic networks of sound wavelengths are ideal substitutes, as sound signals transmit well by water and require less power than RF.

Deployment and maintenance of UWSNs as shown in Figure 1 is more challenging than land-based wireless sensor networks. In the underwater world, first acoustic signals are used. A bandwidth is smaller and the time is longer. Furthermore, because of water dynamics that involve route adjustments, UWSN nodes continue to drift. Approximately many decades of kilobit per second are used for underwater acoustic channels, and hundreds of kilobits per second can be achieved through short-range array measuring many tens of meters. In addition to these intrinsic properties, other factors such as path loss, vibration, multipath, and doppler propagation influence subsequent acoustic communication channels.

The underwater sensor network typically consists of multiple autonomous and individual sensor nodes for the processing and transmission of data to the UW-sink. The greatest difficulties in using such a network are the costs: the computer ability, the memory, the communication range and, particularly, the limitation of each node's battery resources. UWSN's lifespan is effectively reduced because of an increase in the number of sensor nodes stopped by energy waste. High power consumption, therefore, makes long operating times without modifying system output a specific challenge for researchers.

In this paper, we present a multi-objective multi-verse optimization algorithm to improve network life, MOMVO aims to reduce energy consumption by deploying the node at the best location. From the results, it can be suggested that MOMVO with LEACH can still provide a network life slightly higher than the SEP and Z-SEP algorithms.

Motivated by multi-faceted concepts to solve network optimization problems, multi-objective multiple verse optimization algorithms. With the generation of a random solution group inside a multi-version optimizing algorithm, the optimization process starts. Positioning in solutions with high inflation values leads to solutions with low inflation values at any point in iteration change. In the meantime, each solution faces random calls to minimize energy usage to achieve the best solution. It is repeated until the termination conditions, i.e. the maximum number of iterations, are satisfied

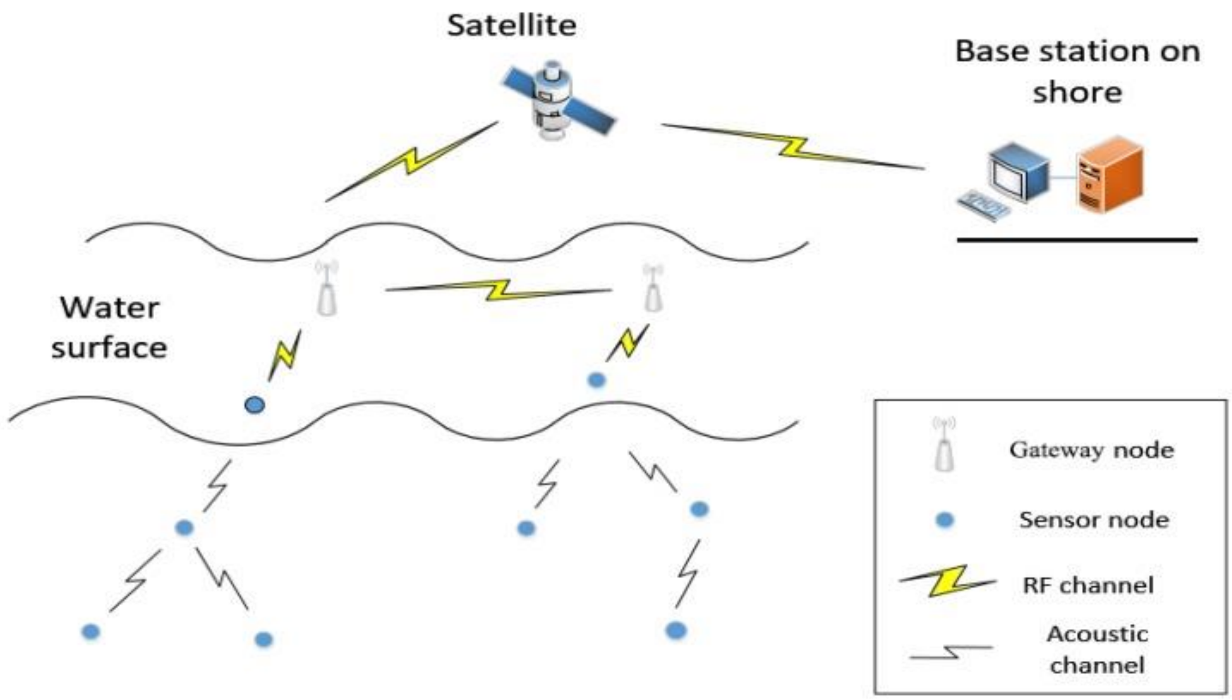


Figure 1: Underwater optical wireless sensor network

The multi-objective multi-verse optimization algorithm is recognized as one of the latest methods for optimization that have several advantages of being easy to structure, getting a full-energy adaptive handle parameter to prevent stagnation of local optimization. The Multi-Objective Multi-Second Optimization Algorithm was developed and used to address the problem of network growth planning. The proposed Multi-Objective Multi-Second Optimization Algorithm Superiority has been shown to generate safe transmission paths and enhance network life with minimal power consumption.

II. Related Work

Energy performance is a key feature in the network of underwater wireless sensors (UWSNs). Since sensor nodes come with batteries which in hostile underwater environments are hard to replace or recharge. The VBF team introduced in 2012 an energy-efficient protocol to extend the VBF protocol's network life. This method[1] uses knowledge about the location and energy status of a sponsor node. The vector routing protocol (LE-VBF) redefines how to use energy data to measure the desired object. The mean energy and location information is stored in every data packet.

Badia et. al[3] implemented an ILP to clarify the issue of deployment optimization. To monitor medium access and avoid interruption, a connection schedule was used. The connection scheduling restrictions, however, assumed packets would travel within a single time frame from their source to the sink to generate excessive timescales. [2] Hybrid power balance strategies were proposed by the authors for sparsely used networks. This was intended to deploy all nodes linearly and to adjust transmission mode between direct and hop-per-hop, residual energy information was used to ensure that nodes would absorb their energy in a controlled way.

The literature has been concerned with optimizing the underwater sensor network life. Jurdak et. al [4] suggested that battery life in shallow underwater networks be improved using topologically dependent frequency allotments. Zhu et. al[5] proposed using power management, multi-path routing, and packet combinations to reduce power costs and increase reliability by maintaining low end-to-end latency.In [6], In a network simulation method (NS2), Harris and Zorzi also proposed good modeling of acoustic channels. The model was essential for the simulation work of submarine models. The model separates the submarine model into four sections, physical parts and channels.Since the system is fundamental, the fading and multi-path arrivals of the underwater signal are not considered.

Since the battery operates wireless sensor nodes, higher energy consumption is causing a serious problem. In the submarine wireless sensor networks, therefore, energy efficiency has become a big concern. A late tolerant protocol is proposed in [7], known as the late tolerant dolphin data scheme. This scheme was developed for systems and applications with delay-tolerant. Both sensing nodes remain static in these protocols, and the data sensed by static nodes are passed to the data dolphin as courier nodes. The Vehicle-Based Transmission (VBF) is one major routing protocol that mobile UWSNs suggest. The approach is geographical and assumes that all sensor nodes are aware of their location and that each data packet contains information about the source, destination, forwarder node as well as a mobility node area.The limited number of nodes involved in the data transmission process and state information is not required for nodes.

Vector-based void evasion (VBVAs)[9] A vector-based protocol was suggested for addressing the void routing issue of mobile underwater wireless sensor networks. For VBVA networks there are two approaches, otherwise vector shifts and backpressures are similar to VBF. There are no other approaches. The [10] multi-sink routing protocol was built with large data packets for reception in a mesh deployment network. The 2D underwater wireless sensor network is almost stationary and just shallow near the sea. The implementation architecture is thought to be a 2-story network topology in which specific sensors act as sensors, computers and media devices. The sensors are in the lower stage and are built into a backbone network that needs data on the onshore station from the sensor nodes.

JSMR[11] not only offers a model for increasing the lifespan of the WSN but attempts also to take advantage of the mobility of the sink over a delayed transmission of data to the base station. Recent work has shown that development and evolution are possible in the field of multi-path routing. REMP[12] proposed a new technique to guarantee high service quality through multi-way routing. The Set Packing and Clustering Technique[13] is an excellent versatility technique for sinks. It is concerned with the new system, with the set packaging algorithm and with the question of a salesperson. The sink separates the region into clusters on the basis of the set packaging algorithm depending on the scheme and decides the routing route between the cluster heads via the Traveling Salesman algorithm. A multifunctional routing approach has been proposed by EART[14] to ensure an improved quality of service (QoS) with testing parameters such as efficiency, timability, and energy in the WSNs. DAMLR[15] is a pragmatic system that uses the Lagrangian approach to build a maximum life span and linear programming algorithm with detailed research.

DCS [16] has implemented a compressive network algorithm for extended network life for innovative, distributed source coding (DSC) and compression sample (CS). To reduce the number of packets to be transmitted, the individual nodes agree on a compression and data promotion strategy. This approach is very useful in achieving an effective compression rate using an adaptive algorithm which is based on an unambiguous cosine transformation (DCT) and an up-and-coming framework.In the domain of wireless multimedia sensor networks (WMSN), QRP[17] uses a genetic algorithm (QGA) and queuing theory to assess the service quality of the path. It assigns weight to the quality of services based on obstruction, energy consumption, and consistency.

LEACH with MOMVO is designed for critical applications in long-term applications when sensor nodes are clustered. The protocol operates in two phases: the first phase of cluster development and the selection of CH based on residual energy. Besides, the random rotation of CH between the different nodes within the cluster is achieved to improve the rapid flow of the node energy sensor. This paper optimizes the life of the underwater sensor by integrating the LEACH with the multi-objective multi-verse optimization algorithm.

III. Methodology

A. Problem Statement

Due to the problems of underwater communication, underwater Wireless Sensor Networks (UWSN) have become a common research subject. The optimized route through the sensor nodes for the transfer of the monitored data to the onshore terminal is a key goal of any underwater network. The transmission cycle requires energy from every node and energy is limited in UWSNs. The most challenging task in the underwater wireless sensor network is, therefore, energy efficiency. The main focus of this paper is on optimizing network life, path loss and minimizing power consumption in UWNNs.

B. Assumptions

In our simulation, we make some assumptions for Enhancing the network lifetime as well as in reducing and minimizing the consumption of power using MOMVO with LEACH.

Assumptions:

1. After being deployed on the ground, sensor nodes and UW-sink shall be called stationary.

2. The network is expected to be homogeneous and each sensor node has the same initial energy.

3. In terms of computational power and energy, the underwater sink is not inadequate.

4. The underwater sink is located at the surface.

5. Every node tests environmental factors at a static rate and transfers them to the recipient nodes periodically.

6. Either in sensor mode, every sensor node is capable of observing environmental parameters and transmitting CH to the underwater sink.

C. Proposed workflow:

Step 1: Clusters creation

By usingthe LEACH algorithm to form clusters as sown in Figure 2.

1. Each cluster C(i) contains several nodes, i=1, …, N
2. In the beginning, entire nodes have an equal quantity of energy.

Step 2: Selection of cluster head (CH)

Step 3: Transmission of Data

1. Transmission Intra_cluster
2. CHs to the uw-sink transmission of data

Step 4: Network Lifespan Formulation

Network lifespan is generally characterized as the earliest interruption of network functionality by a fraction of the node.

Optimization Objective: We minimize the network decay rate to maximize network life.

The critical nodes, $C \subset V$, The overall network decay rate μ corresponds to one of its primary node's fastest decay rate. The decay rate βv of the following is specified in any critical v node: $\beta v = \pi v / \varepsilon v, \forall v \in C$

We are formulating the constraint as follows: $\beta v \leq \mu, \forall v \in C$

For the following objectives, we have solved the problem,

1) min end-to-end delay $\alpha = 0$

2) max network lifetime $\alpha = 1$

3) trade-off objectives with $\alpha = 0.2$ and 0.1

MOMVO Algorithm

Multi-objective multi-verse optimization algorithm isinspired by multi-faceted ideas to address network optimization issues. The optimization processstarts with the generation of a group of random solutions in a multi-verse optimization algorithm.Positioning in solutions with high inflation rates results in solutions with low inflation values at any step of iteration change.Meanwhile, each solution is faced with random transmission to reduce energy usage to the best solution. This process is repeated before the final conditions are reached, i.e. the maximum number of iterations. The MOMVO Flow Chart is shown in Figure 3.

```
Pseudocode for MOMVO
----------------------------------------------------------
S- Sorted solutions
N- Normalize fitness function
For each  i do
BHoleindex=i ;
Foreach j do
r=rand_val([0,1]);
if r;N(Ui) then
WHoleindexi=Roulette wheel mechanism(-N);
U(BHoleindex j)=S(WHoleindex j);
end if
end For
end For
```

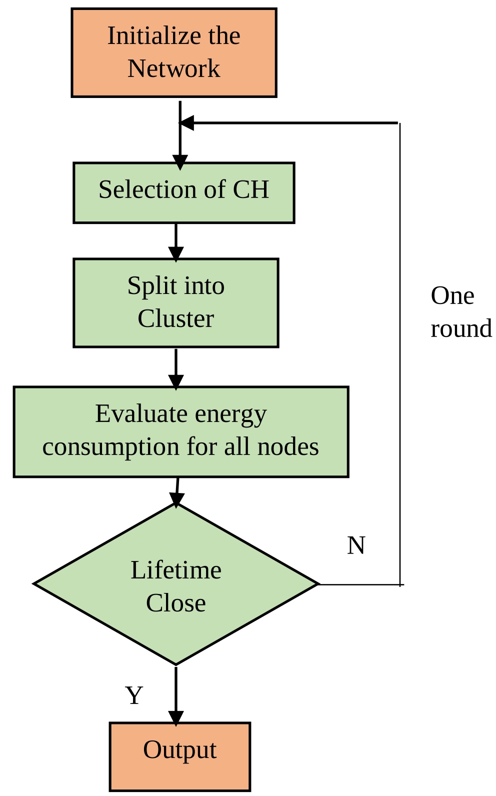


Figure 2. Flow diagram of LEACH

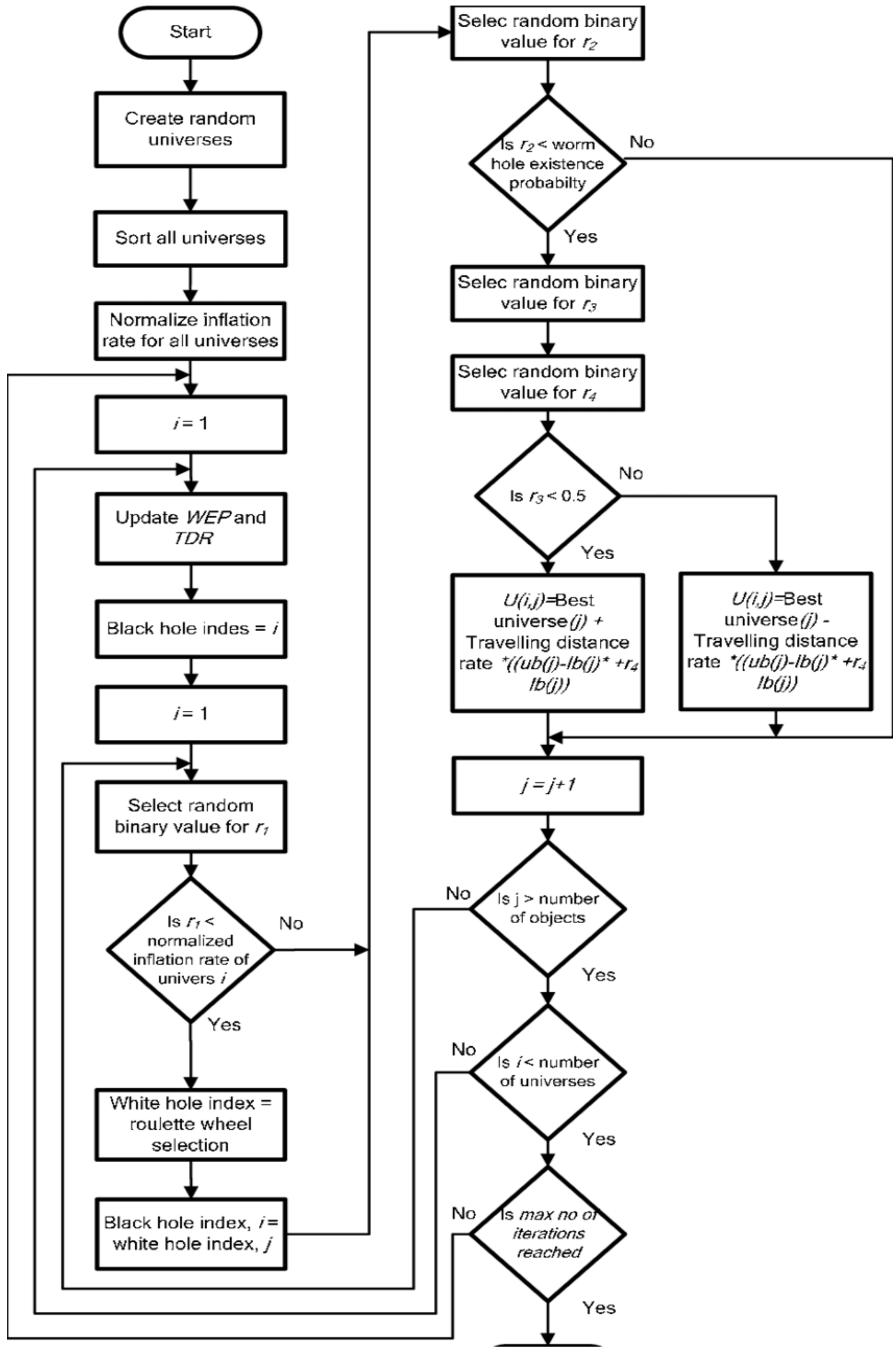


Figure 3. Flow diagram of MOMVO

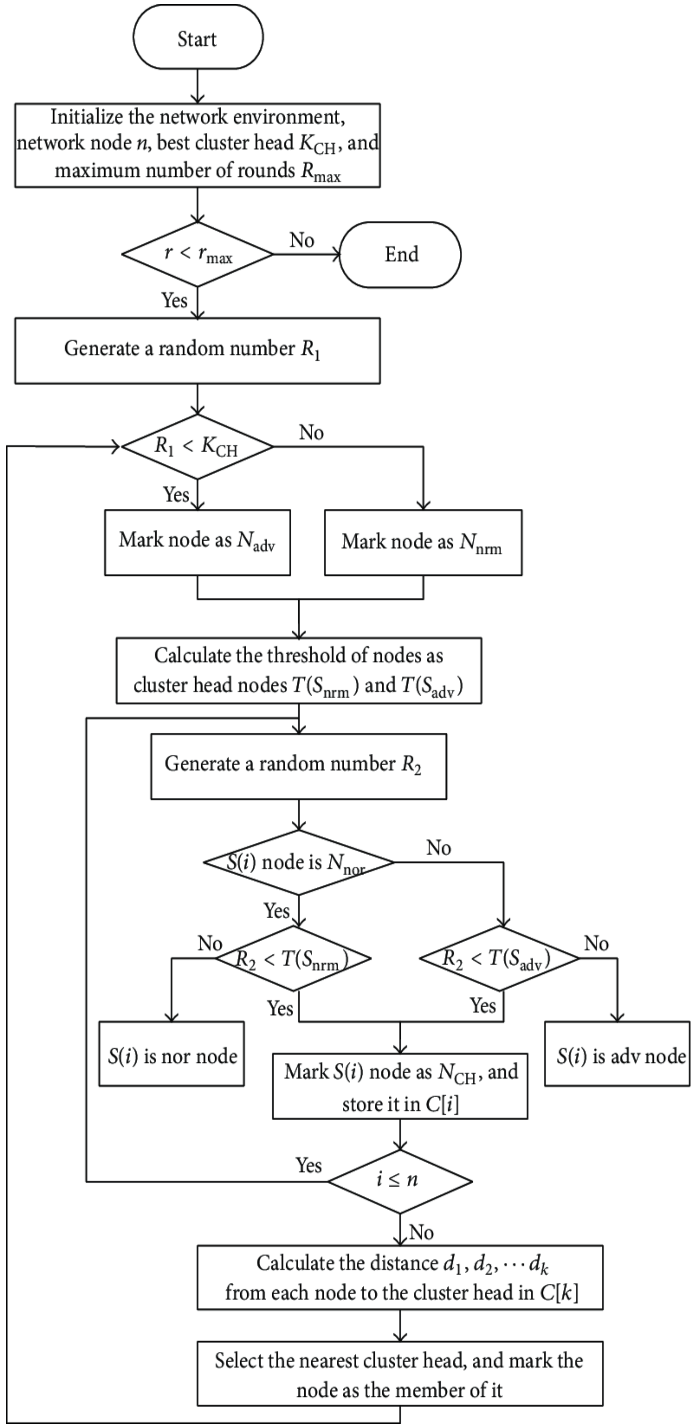


Figure 4. Flow diagram of SEP Protocol

Stable election protocol (SEP) in which node in the network has a distinct energy level. In SEP, the initial power in all nodes is not the same. There are two types of nodes are present in SEP one is a normal node and the other is an advanced node. Usually, the advanced nodes are nodes which are having additional energy t normal nodes. In SEP, one of the important factors which depend on the probability of nodes is the threshold value for cluster creation. By using the threshold values, each node generating a random number so if the value generated is lower than the threshold value, then the node is converted to CH.. Figure 4 displays the flow diagram of the SEP algorithm.

Z-SEP Technique

To transfer the data to the base station, Z-SEP uses two techniques.

• Direct communication.

• Cluster head transfer

Direct Communication:

The normal nodes sense the world, gather data and send it directly to the base station.

Broadcast by Cluster head:

Optimum SEP compliant cluster size. The head cluster gathers the data from the member nodes and aggregates the data to the base station. The choice of cluster heads is very critical. A cluster is only formed in advance. Suppose the number of CLopt clusters is optimum. And n is the advanced number of nodes. The highest chance of cluster in SEP, the head is :

$$Hopt = \frac{CLopt}{n} \quad (1)$$

In the current round, every node selects whether or not to transform into a cluster head.

The node produces the altered number from 0-1. The number is chosen to become the cluster head if this random number is less than or equal to the threshold of the node.

Threshold Th(n) is given by

$$Th(n) = \begin{cases} \frac{CLopt}{1-CLmodopt(rXmod\frac{1}{CLopt})} & \text{if } n \in N \\ 0 \end{cases} \quad (2)$$

N is the collection of nodes that were not cluster heads in the last rounds of 1/CLopt.

It is suggested in [2] that advance nodes should become a cluster head

$$CLadv = \frac{CLopt}{1+(\alpha.m)} X(1+\alpha) \quad (3)$$

The threshold for advance nodes is

$$Th(adv) = \begin{cases} \frac{CLopt}{1-CLopt(rXmod\frac{1}{CLopt})} & \text{if } adv \in N' \\ 0 \end{cases}$$

N 'is the number of advanced nodes which in the last 1/CL advance rounds were not cluster head.

After the selection of CH, the cluster head will transmit an advertising message to all nodes. In the current round, the nodes receive the message and determine the CH they belong to. Figure 5 displays the flow diagram of the Z-SEP protocol.

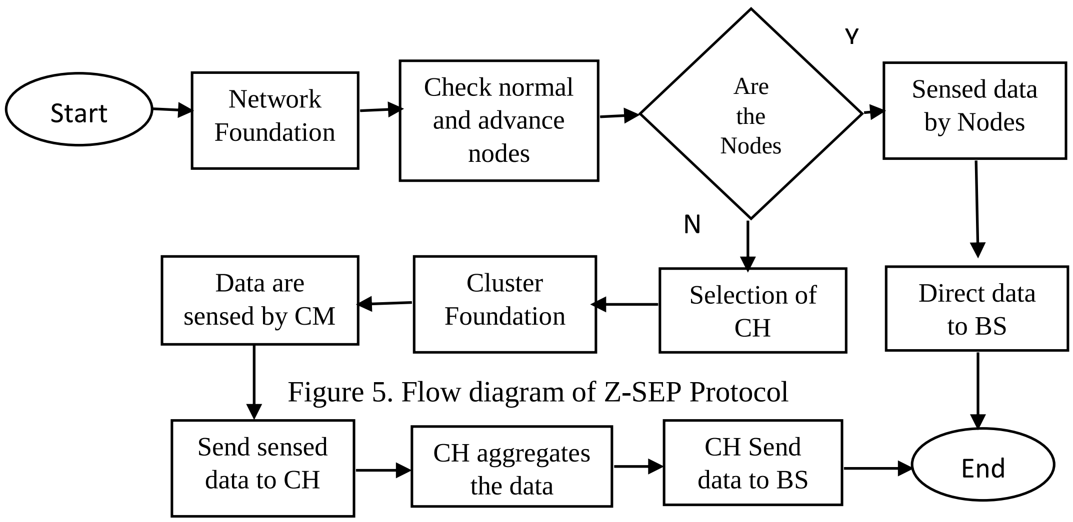


Figure 5. Flow diagram of Z-SEP Protocol

IV. Results of simulation

Simulate the proposed method in the network area with measurements of 100m×100 m and 100m nodes positioned for their energy in particular regions. The base station (BS) is at the center of the network area.MATLAB is used to perform simulations. The Simulation settings are shown in Table 1.

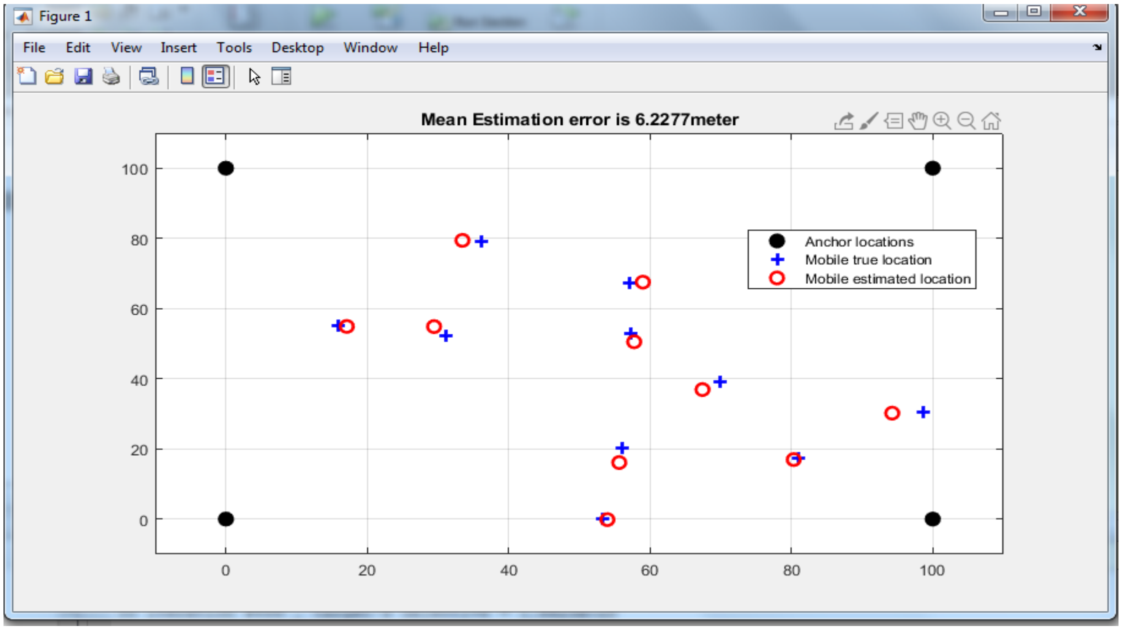
Table 1. Parameters of simulation

Parameters	**Values**
Size of the Network	(100*100*100) m3
Nodes count in Network	100
Energy at the beginning	10.1 J
Sink coordinates	(60, 60,150)
Packet size	2000 bits

The sensor data is usually interpreted with the location of a sensor node in the underwater environment such as target tracking, physical status monitoring or event reporting. Take into consideration the location of the network sensor node and the nodes known as the sensor anchor node

Figure 6. The Mean Estimated Error 6.22

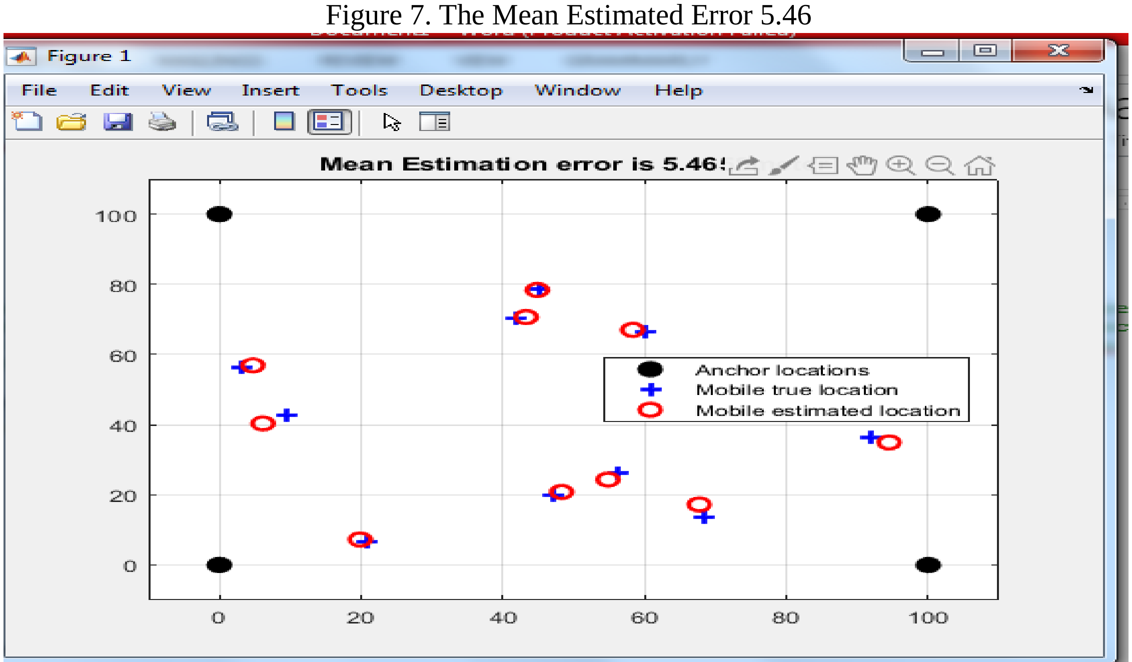
Calculate the Mean Estimation Error for the simulated Network to discover the information for the localization. Figures 6, Figure7 and Figure 8 show that the estimated mean error 6.22, 5.46 and 4.99 decreases, respectively As for all



algorithms, the number of nodes increases. When other parameters remain the same, increased number of nodes contributes to higher average connectivity.

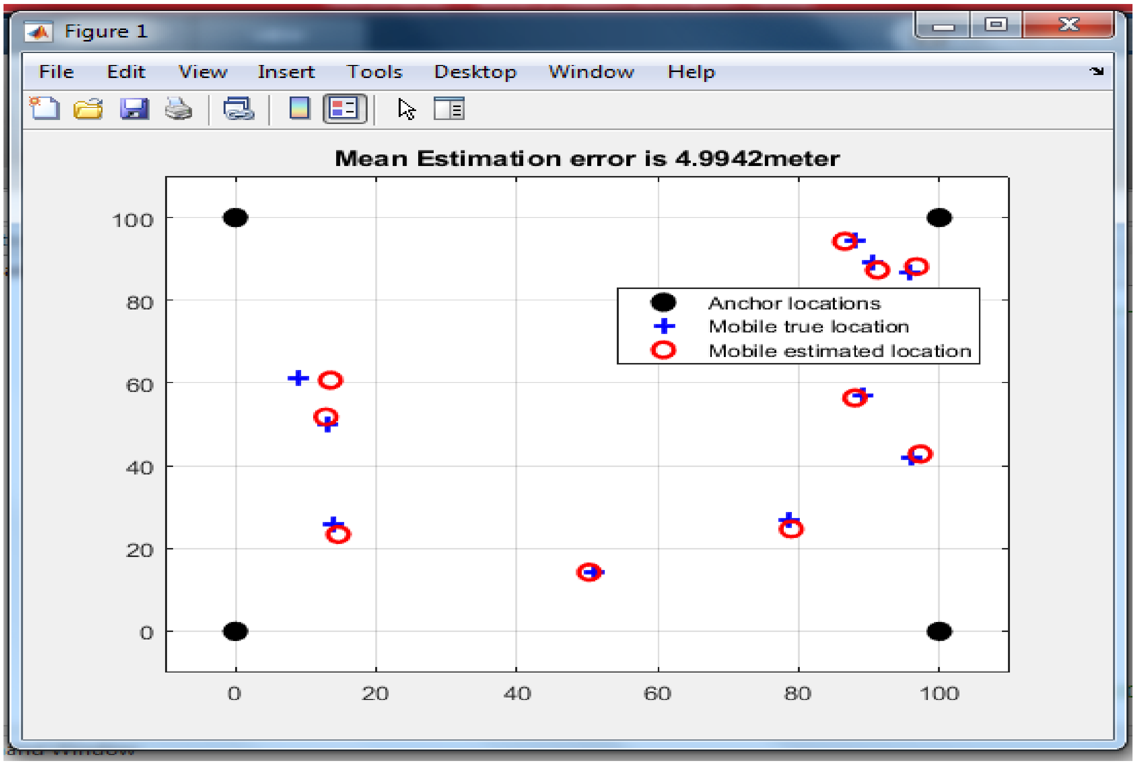
Figure 7. The Mean Estimated Error 5.46

A non-



uniform location of the sensor node is selected to calculate the average expected error. Once a random location for a sensor node is set, various iterations will be applied, but only a limited number of iterations will be used in the first case. The deviations from 2,7499 m to 6,4789 m of the mean estimated error are greatly decreased by the average estimated error.

Figure 8. The Mean Estimated Error 4.99

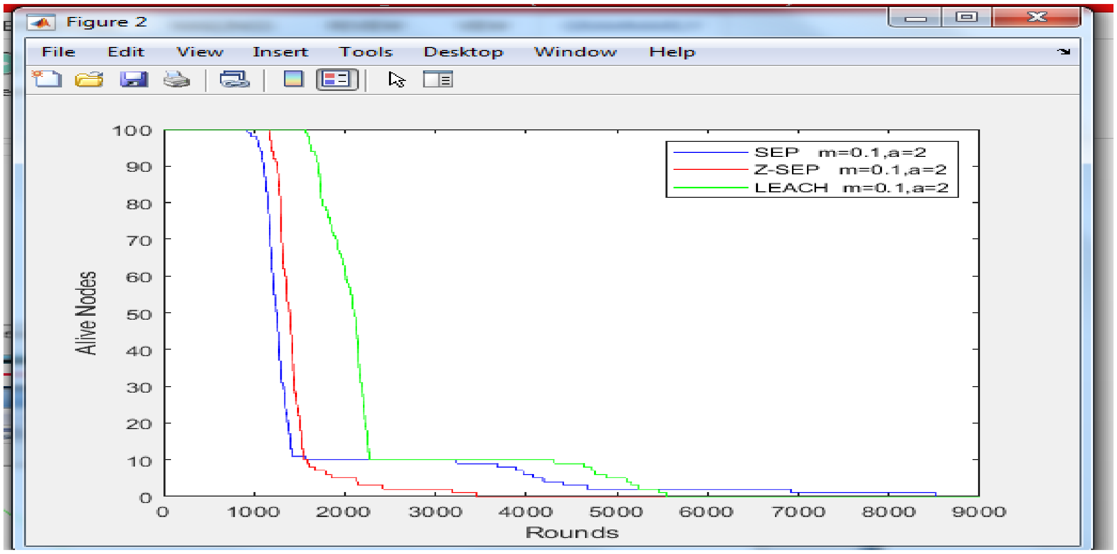


The position method was performed using the distance estimate between the sensor nodes and the anchor nodes in distance measurements. Mobile sensor nodes can be used in this region free of charge since the sensor nodes are dynamic not in a certain location. The mobile node number is 10 and the mobile node number 4. The four anchored nodes can be placed on each sensor node's four vertices in a network. The method is assessed by multiple iterations and the average approximate error is calculated after the position of the sensor nodes. The process is repeated several times in this case, but only four iterations are taken into account. Because of the average, the calculated error often varies from 2,7499 m to 6,4789 m between the four iterations shown in figure 6.

Due to the fluid nature of water, maritime activities and many other issues, the fluctuation in the mean estimated error are induced, but still, the method is well accurate.

Figure.9 The Number of alive nodes against rounds for LEACH, Z-SEP, and SEP.

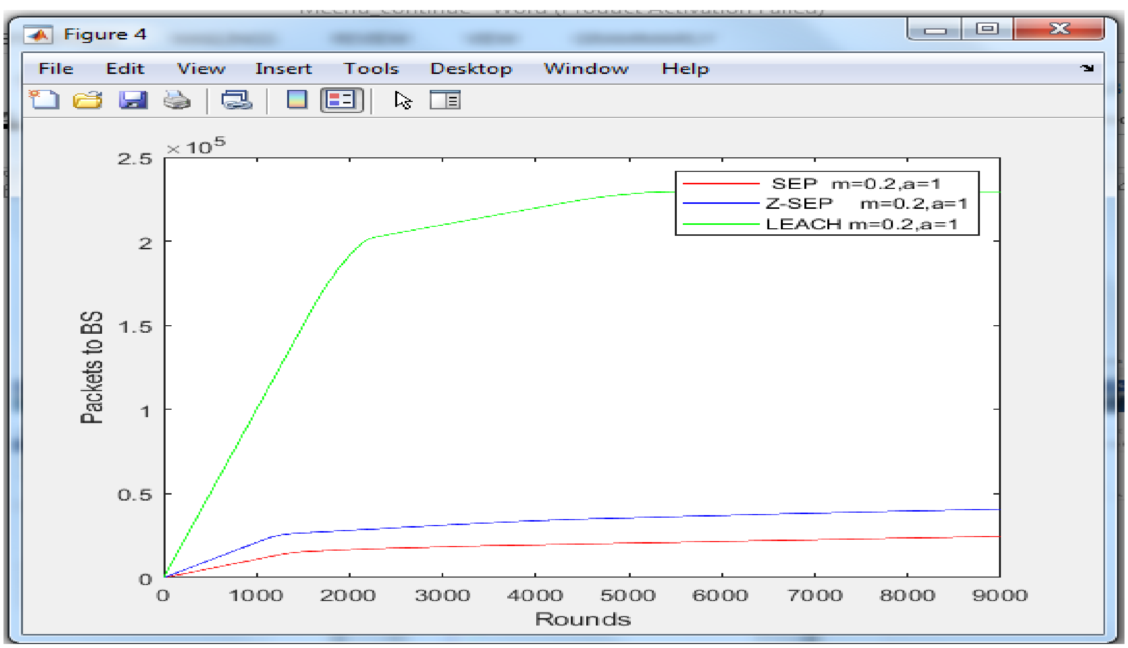
The tests of LEACH and MOMVO, SEP, and Z-SEP are compared here. Our simulation goals are to analyze



LEACH with MOMVO, SEP, and Z-SEP for stability cycles. • LEACH, SEP, and

Z-SEP outputs are also investigated. In a two-level heterogeneity, Z-SEP is better than SEP since Z-SEP has a weighted probability of cluster head selection for standard nodes and advanced nodes.Figure 10. Throughput for SEP, Z-SEP, and LEACH

LEACH performs better than SEP and Z-SEP since nodes directly communicate to the base station as indicated in Figure 9.As in the clustering technique, CH consumes energy in the form of receiving data from cluster nodes.



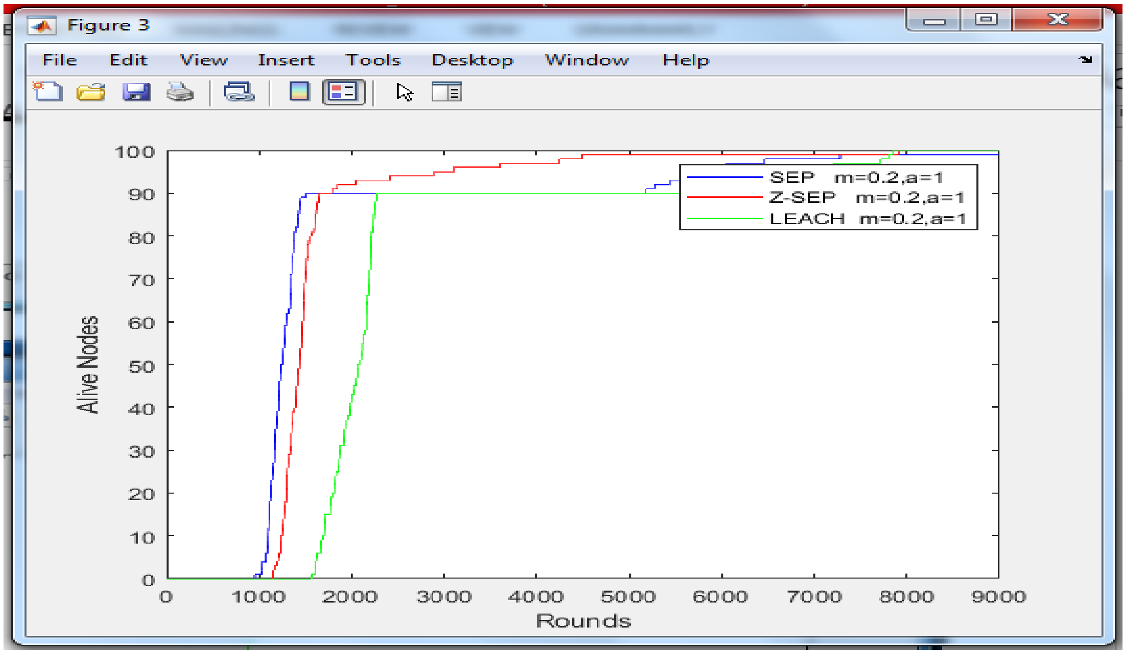


Figure 11. The number of alive nodes against rounds for LEACH, Z-SEP, and SEP.

So this energy is stored in normal nodes as they do not have to collect data and receive data from other nodes, so the energy is not dissipated, increasing the stability period, like that of the cluster head. Illustration 10. Due to the advanced node, network life is also increased. Advanced nodes have more resources than ordinary nodes, and advanced nodes die later. This raises the uncertainty period. The stability of the LEACH cycle is, in both cases, nearly identical, i.e. (m=0.2, α=1)and (m=0.1), α=2), because the nodes in Figure 10 have the same energy, absorb the same energy, and almost die simultaneously.

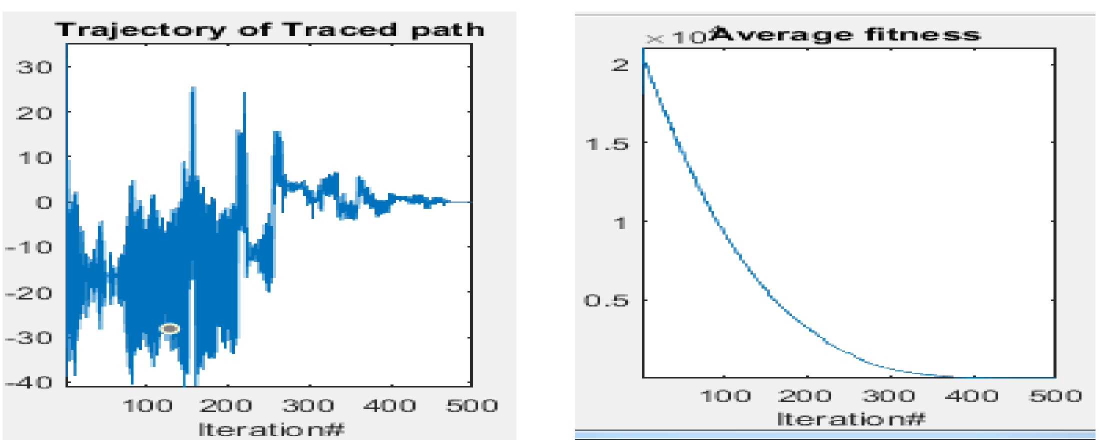
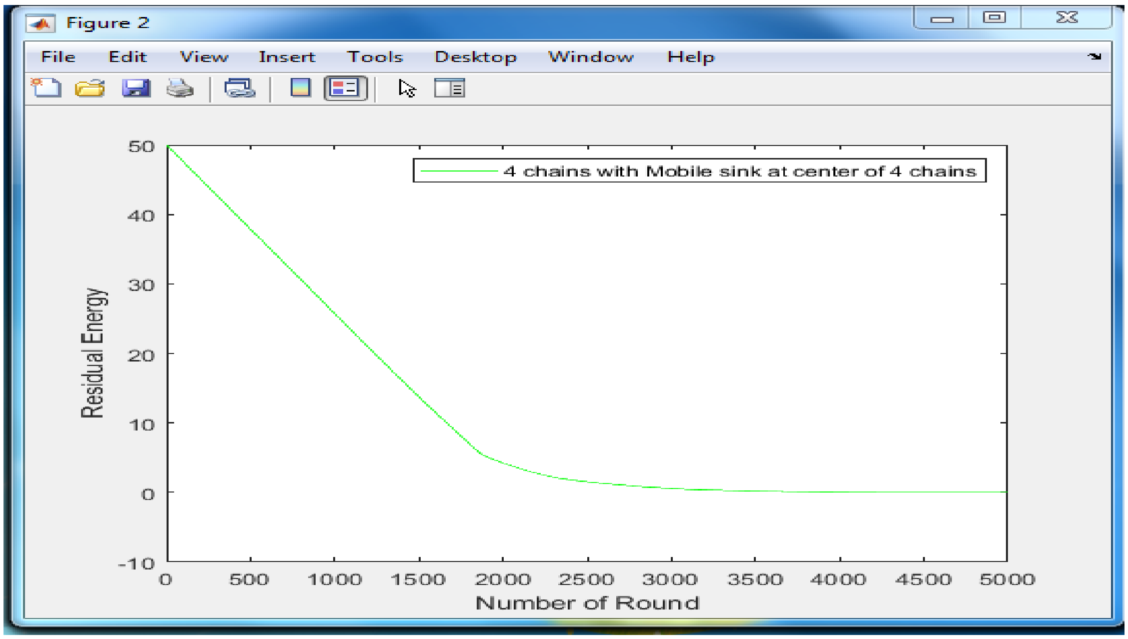


Figure 12. The trajectory of the traced path and fitness function to Optimize the path loss

The network life is increased due to the extra energy of the advanced nodes and the optimized path loss as shown in Figure 12.

Figure 13. Residual Energy versus the number of rounds using MOMVO



The network lifespan is better than previous techniques due to the proficient energy consumption shown in Figure 13.Residual energy will ensure the polished degradation of network lifetime.

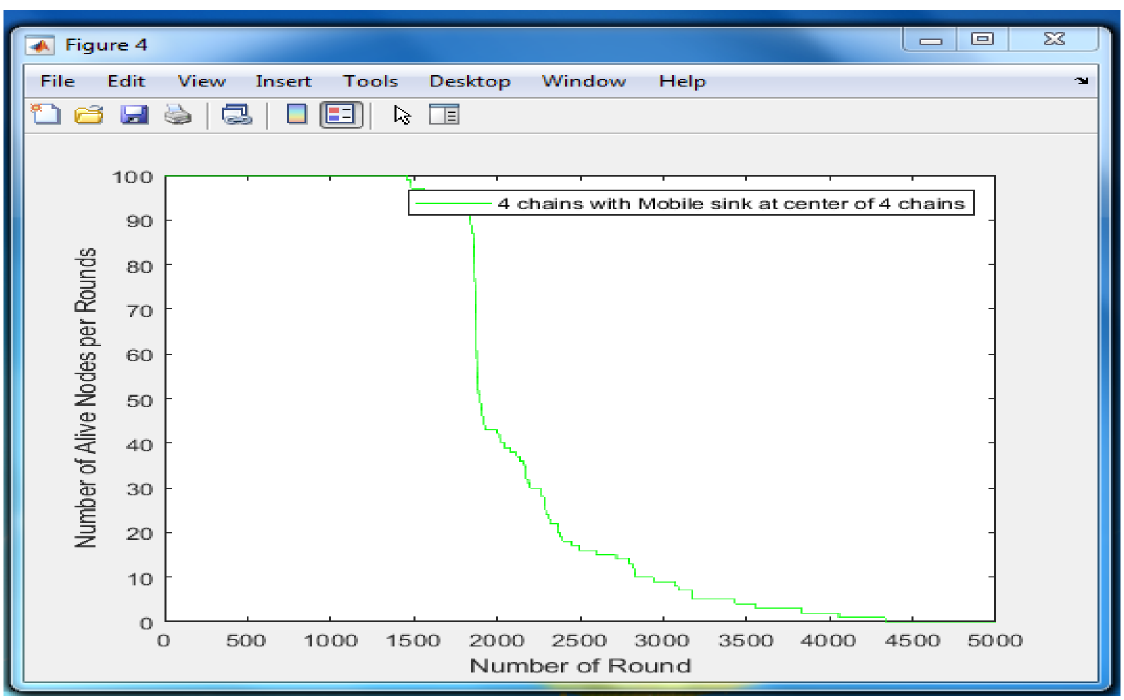


Figure 14. Alive nodes per round obtained by MOMVO

The above Figure 14 illuminates the total number of nodes alive over time, which indicates the lifetime of the network.

V. Conclusion

In this paper, a multi-objective multi-verse optimization algorithm is recommended along with a distance-based localization to optimize network life for the Underwater Wireless Sensor Network (UWSN). Sink versatility has major advantages compared to the static sink to enhance the network's life. Our considerations support the reduction of track loss, as demonstrated by smaller chains between connected nodes in Figure.12. MOMVO aims to reduce energy consumption by deploying the node at the best location, as shown in Figures 13 and 14. From the results, it can be suggested that MOMVO with LEACH can still provide a network life slightly higher than the SEP and Z-SEP algorithms.

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