Energy Efficient Approach for Underwater Sensor Network using Elephant Herd Optimization

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Abstract
Wireless Networks are known to be susceptible from different energy consumption issues and enormous algorithms are devised so far for the escalation of lifetime in the sensor nodes and overall network environment. LEACH or Low-energy adaptive clustering hierarchy is one of the classical approaches that is adopted in many wireless implementations along with the variants of LEACH so that the network environment can be run for long time with more energy in the nodes. For improvement in the span of energy in nodes of underwater network, a novel and energy efficient approach of population based optimization is used in this research work with integration of Elephant Herd Optimization (EHO). In this approach, the behavior of the elephants in selecting their heads is adopted to form the dynamic cluster head in underwater wireless networks. It is found from the results that the EHO based energy optimization approach presents the results effective than classical approach in terms of multiple parameters. In this work, the optimization level of the energy to more than 11% is achieved using Elephant Herd Optimization that is also used in many others domains for engineering optimization.

Keywords – Elephant Herd Optimization, EHO, Energy Optimization, LEACH, Underwater Sensor Networks, UWSN

Introduction

Underwater Sensor Networks [1] are the specialized class of wireless networks [2] which are deployed in the ocean so that the underwater monitoring can be done for different applications including defense, oil exploration, terrorists' movements, minerals exploration and many others. To work on these perspectives, there is need to deploy the sensor nodes with higher lifetime so that there is minimum decay or loss of signals strength.

Following is the traditional scenario of underwater network having assorted constituents deployed in the ocean region with the monitoring cells.

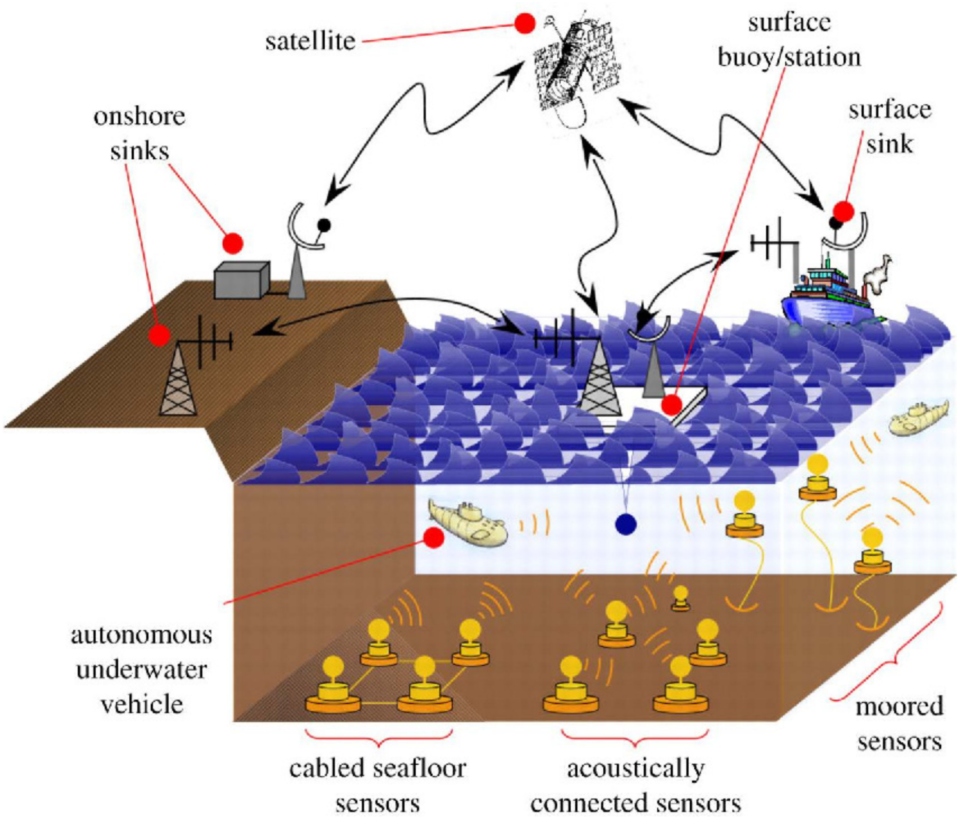

Figure 1: Underwater Sensor (Acoustic) Network

In Figure, the different elements of UWSN are presented including Satellite, Sensor Nodes, Autonomous Surface Vehicle (ASV) [3], Monitoring Center, Sink, Autonomous Underwater Vehicle (AUV) [4] with the signals transmission. All of these elements work and communicate together to share and transmit the signals for specific goals to the base station and controlling monitoring center.

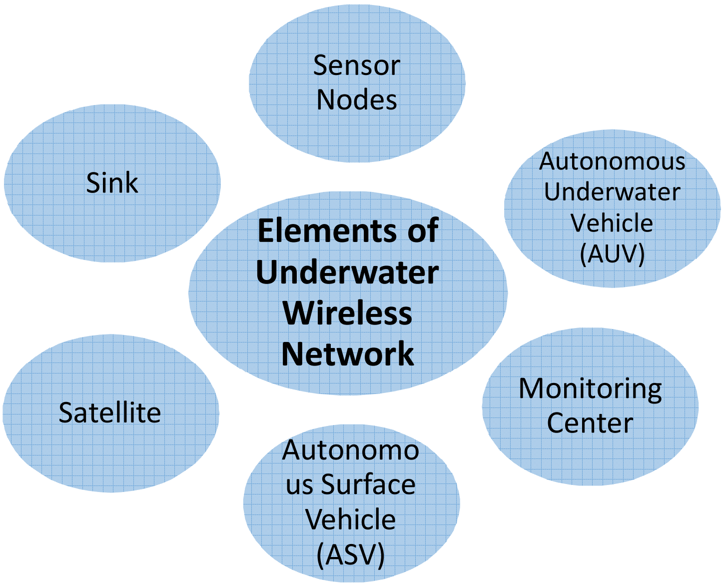

Figure 2: Elements of Underwater Sensor Network

Energy Optimization and Routing in Wireless Environment

The energy and power in the wireless nodes are very limited which makes the network scientists aware with the development of new protocols so that the high performance algorithm for energy optimization can be devised [5]. There are number of algorithms and techniques devised for optimization of energy in UWSN which are having key focus on the cluster head formation so that the minimum energy loss can be implemented in overall network scenario.

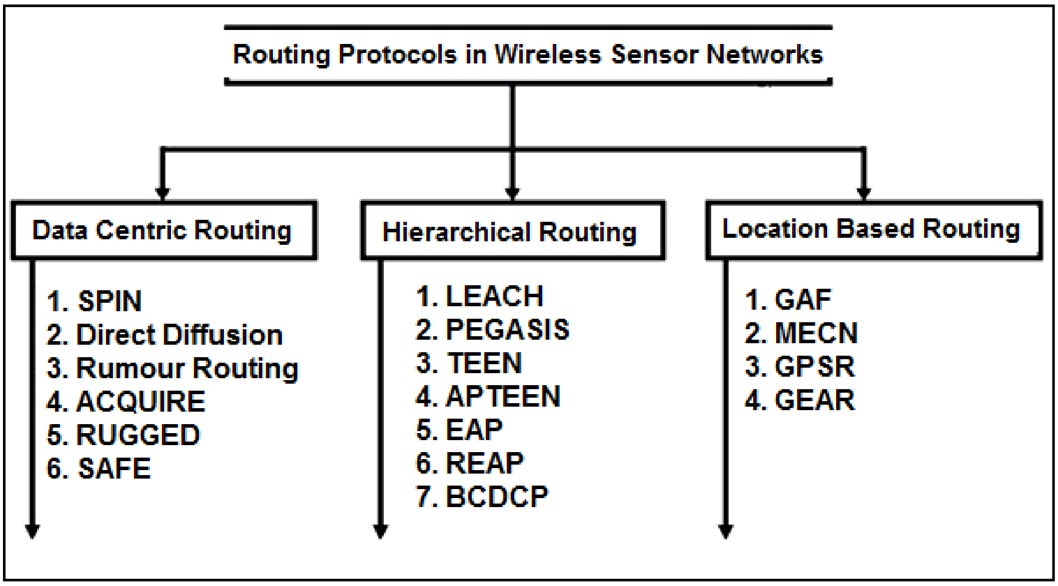

Figure 3. Protocols in Wireless Networks

Low-energy adaptive clustering hierarchy or LEACH is one of the prominent protocols for energy optimization in the wireless sensor networks [6]. LEACH encapsulates the properties

ISSN: 2229-6913(Print), ISSN: 2320-0332(Online)

including threshold value, TDMA based communication, cluster based aggregation, direct communication by the cluster head to the node or sink. Following are the excerpts from the key routing protocols in wireless sensor networks. Low-energy adaptive clustering hierarchy or LEACH is one of the prominent protocols for energy optimization in the wireless sensor networks. LEACH encapsulates the properties including threshold value, TDMA based communication, cluster based aggregation, direct communication by the cluster head to the node or sink.

SPIN – Sensor Protocols for Information via Negotiation (SPIN) is a d Data-Centric routing approach that is based on the negotiation family with the elimination of redundant data. This family avoids the limitations of Implosion, Overlap and Resource Blindness as key obstacles in the traditional flooding [7].

Direct Diffusion – The implementation of data aggregation is done at each node. The advertising of data is done after confirmation from base station (BS) [8].

Rumour Routing – The routing of queries is done to the events with the acknowledgement from the event to which the query is transmitted [9].

ACQUIRE – Active Query forwarding In sensoR nEtworks or ACQUIRE follows the approach of active query routing that is transmitted to the network to fetch the solution. The query is transmitted to each node and multiple hops to resolve the query [10].

RUGGED – It is RoUting on fingerprint Gradient in sEnsor networks. It is gradient based routing that relies on the utilization of fingerprint associated with the event for logging and tracking [10].

PEGASIS – It refers to Power Efficient Gathering in Sensor Information System with the key focus on energy efficient approach in the wireless environment. The approach grants the local communication and coordination in the nodes so that minimum bandwidth and energy can be consumed [10].

TEEN – Threshold sensitive energy efficient protocol or TEEN focuses on the grouping of sensor nodes so that the cluster formation can be done with the generation of cluster head to lead the cluster communication [10].

EAP – Energy Aware Routing Protocol (EAP) is another class of hierarchical protocols in wireless sensor networks for the lifetime improvement and optimization of the energy in wireless environment. EAP presume that the locations are not known to the sensors and these sensors communicate using different paradigms of information including Global Positioning System (GPS), Positional Algorithm and Antenna [10].

Elephant Herd Optimization (EHO) for Energy Efficiency in UWSN

The problem definition and research gaps while identification of the problem is that the energy optimization is quite a big domain that is under research and still huge energy loss scenarios occur in the underwater sensor networks. The earlier is having assorted lacks in multilayered and multi-dimensional model for energy optimization and communication channels.

This work is having the key focus on the implementation of population based approach to form the dynamic cluster heads in underwater sensor network environment. The approach of Elephant Herd Optimization (EHO) [11] is presented with the behavioral analysis of the elephants in selecting their female head in their herd.

Matriarch Elephant – The highest level of element in the elephants in terms of higher age factor is the matriarch elephant that becomes the head or leader or cluster or group in the clan. High Energy Cluster Head is analogous to Matriarch Elephant that follows the process

ISSN: 2229-6913(Print), ISSN: 2320-0332(Online)

similar to formation of head in the clan of elephants. Based on the highest energy and more lifetime, the cluster head the chosen so that the overall scenario or network can be preserved for highest time span. The Approach of Elephant Herd Optimization (EHO) is used for the optimization of results. EHO is one of the prominent metaheuristic approaches which can be used for global optimization of results and selection of Cluster Head.

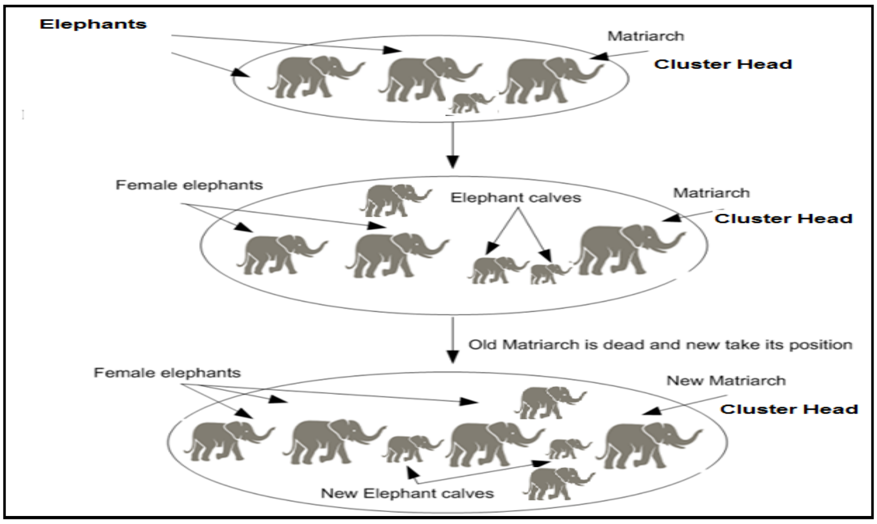

Figure 4: Behavior of Elephants in the Clan for Selection of Head

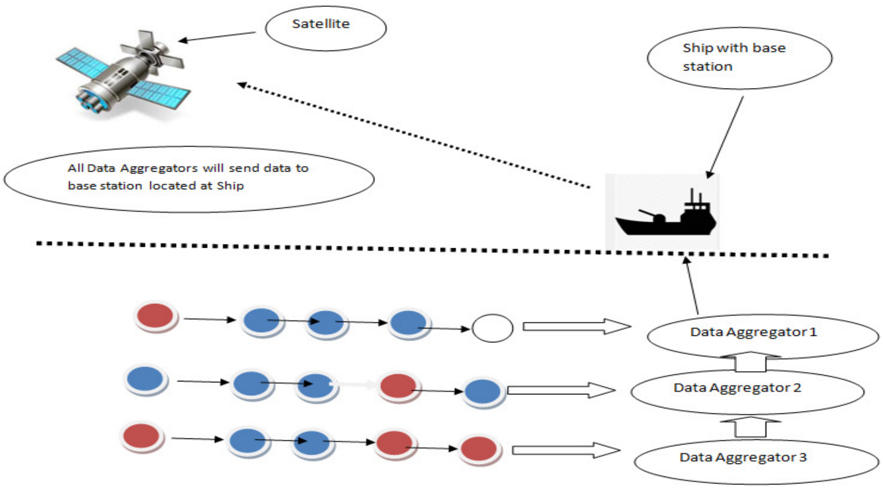

Figure 5. Flow of the Work

Figure 5 depicts the flow of work with the multiple phases of data aggregation and the transmission to base station by which the overall energy optimization is achieved. The work is having enormous advantages as compared to the traditional approaches including there is higher degree of optimization with the threshold analysis of multiple nodes so that the cluster head formation can be dynamic. The shuffling or changing of the cluster head to avoid any type of attack to disguise the cracker of intrusion attempts. The nature inspired approaches are always effectual in terms of minimum delay and higher performance in the multiple scenarios. The repeated flow in the path makes sure the genuine or authentic river formation or simply network path for traversing of the data packet in secured channel

Process and Flow

Step 1: Identification of sensor nodes with the segmentation of the type of nodes. This is analogous to the evaluation of elephants in EHO. Each sensor nodes act as the elephant and the EHO optimization initiates.

Step 2: Based on the type of the sensor node and its current energy level, the best fit sensor is fetched to form the cluster head on its current energy and historical records. This is similar to the extraction of Matriarch Female Candidate in the Elephants Clan.

Step 3: The iterations process initiates with the lifetime of network and regularly checking the life of each node and current energy level. The specific nodes are used to keep track on the information of each node with the cluster association. The optimization parameters for Female and Male Objects are set.

Step 4: The cluster head is used to maintain the group of nodes in its cluster or clan. Female Candidate from Elephant Herd leading the group deemed as Cluster Head.

Step 5: The use of common identifier to each node is done so that the demarcation between normal node and cluster head or clan head can be done. The matriarch is used to identify the group head.

Step 6: The destination node is identified by the cluster head or elephant head in the EHO. This is done so that the authenticated nodes can be having access to the private signals. In case of any sniffing, the packet or signals are rejected by the elephant head or cluster head so that higher security and minimum energy loss takes place.

Step 7: The integration and maintenance of routes is decided by the cluster head so that only authenticated path can be set and decided by the cluster head.

Step 8: The shortest path with higher degree of security is selected by the cluster head to achieve the performance and minimum energy decay. The refining of results using EHO and Threshold Analysis initiates with the process of error removal using fitness score.

Algorithm Elephant Herding Optimization (EHO)

1. ***Initialization.*** *Generation of Individuals; Division of Elephant Population to n number of Clans (Groups); Calculation of the Fitness Score with Each Individual; Setting up the Counter i=1 and Maximum Value of Population in Current Clan (Group) MaxPopulation*
2. ***while*** *i < MaxPopulation do*
    a. *Sort solutions as per the fitness score*
3. ***for all*** *groups-clans g_i do*
4. ***for all*** *solutions m in the group g do*
    a. ***Update*** *x_{gi},m and generate x_{new}, g_i, m using Fuzzy Fitness*
    b. ***Select and Keep*** *better solution between x_{gi}, m and x_{new}, g_i, m*
    c. ***Update*** *xbest and generation of x_{new}, g_i, m using fitness score*
    d. ***Select*** *the best solution and set in x_{best}*
5. ***end for***
6. ***for all*** *group-clans g_i in the population-set do*
    a. ***Replacement*** *of the worst solution in the group-clan g_i using current score*
7. ***end for***

ISSN: 2229-6913(Print), ISSN: 2320-0332(Online)

*a. **Evaluation** of population and calculation of fitness*
*8. **end while***
*9. **return** the best fit solution x_{best} in the group-clans*
*10. **If** optimal solution achieved. Stop else go to step 3*

End

Implementation Results and Outcome

To implement the energy efficient approach using Elephant Herd Optimization, the simulation of wireless environment is done in MATLAB using Biograph toolbox to depict different sensor nodes. Following are the screenshots and output obtained from the simulation scenarios in different time spans

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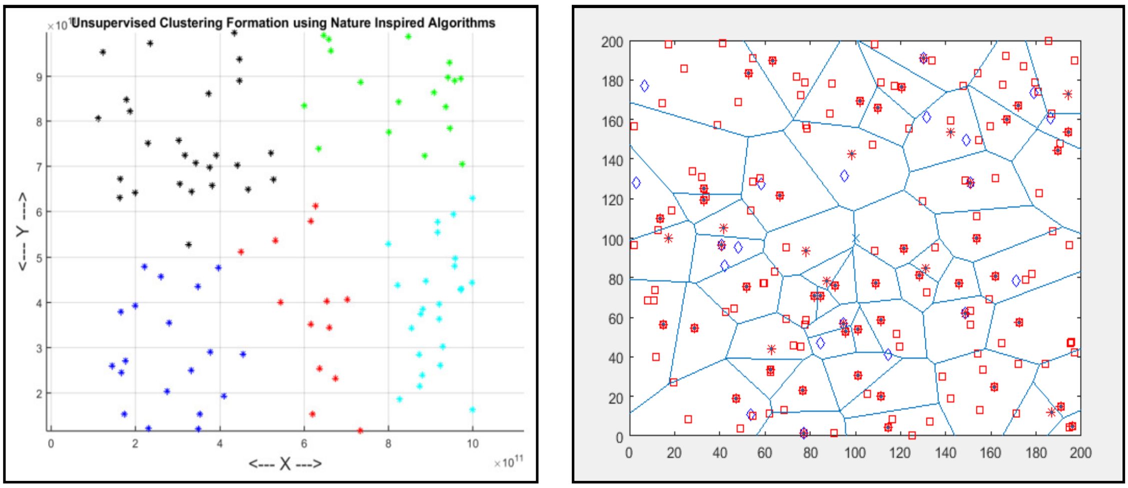

Figure 6. Cluster Formation in Wireless Environment

Figure 6 depicts the scenario of cluster Formation in wireless environment and it is visible in the results that multiple nodes are in the grouping phase for the data transmission and overall energy optimization.

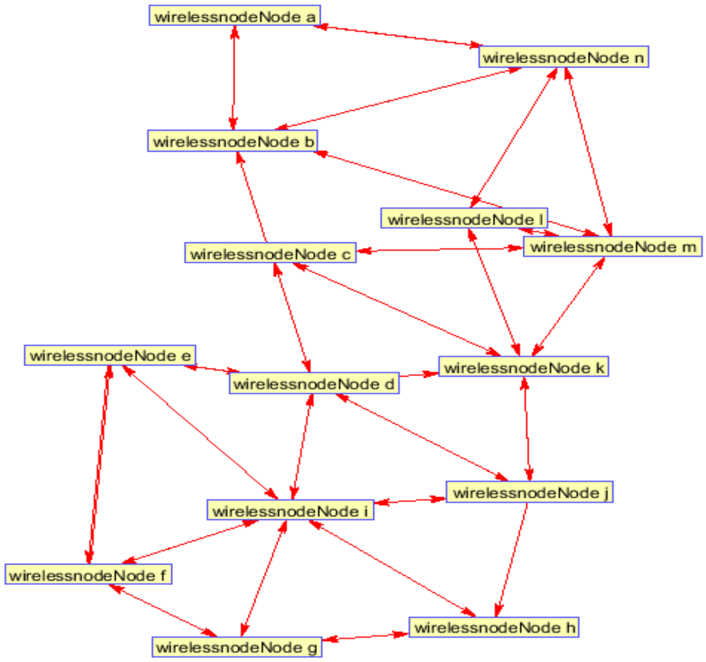

Figure 7. Biograph toolbox view

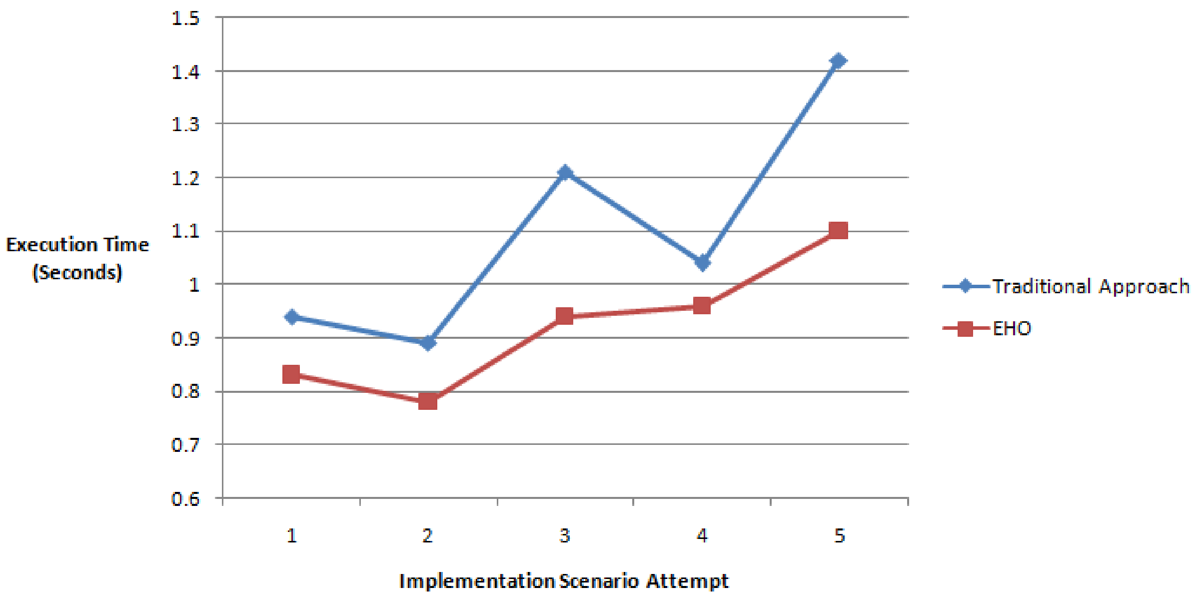

Figure 8. Evaluation of Execution Time

Figure 8 presents the evaluation and comparison of execution Time in the traditional and proposed EHO approach. It is evident from the results that the execution time of EHO is comparatively effective and less than the traditional approach.

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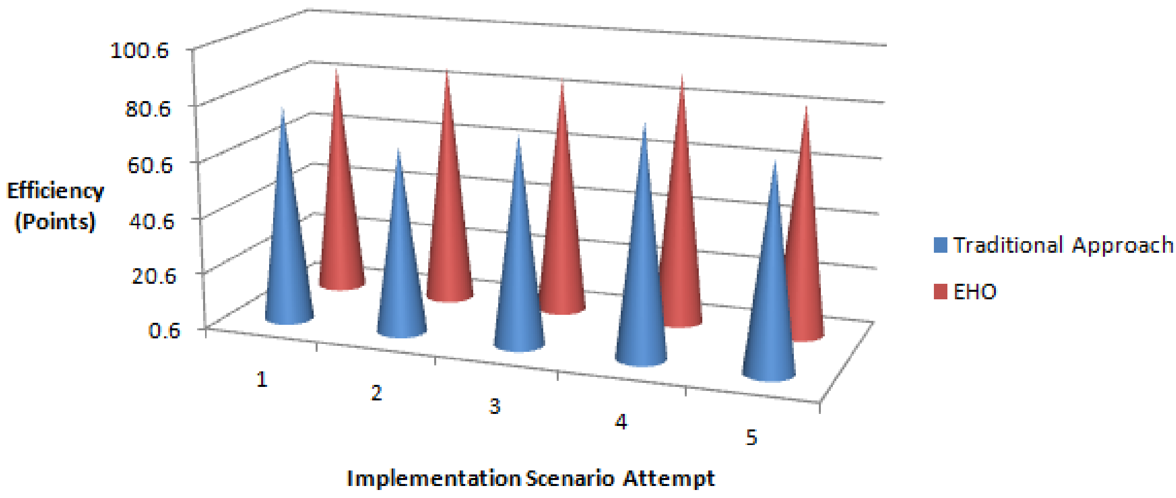

Figure 9. Evaluation of Efficiency

Figure 9 presents the evaluation and comparison of efficiency in the traditional and proposed EHO approach. It is evident from the results that the efficiency of EHO is comparatively effective and more than the traditional approach.

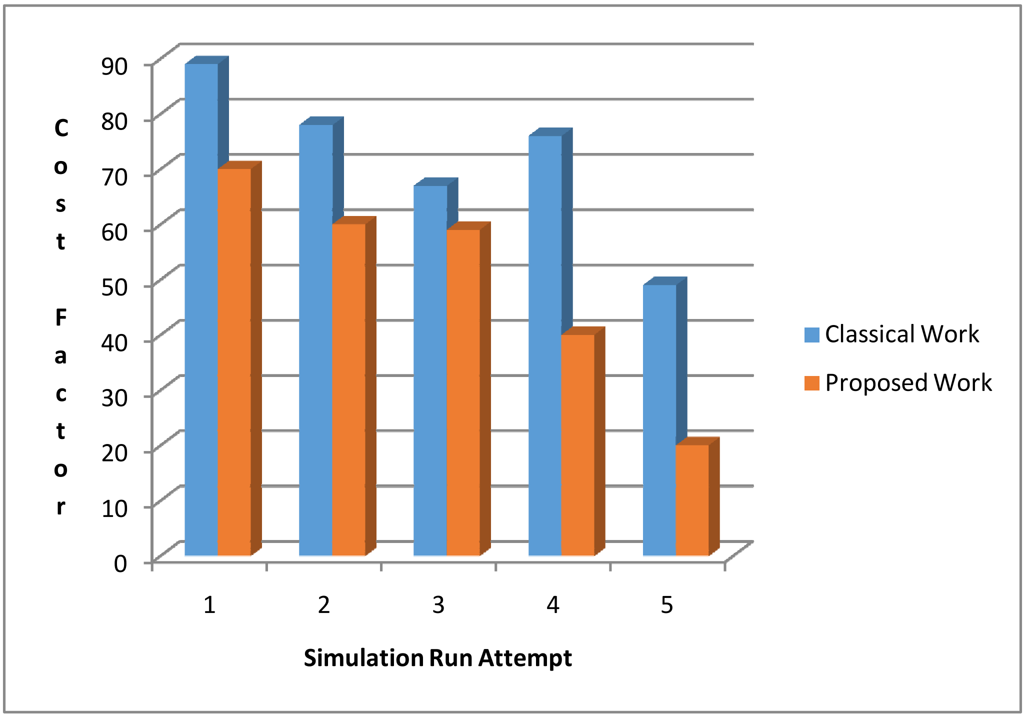

Figure 10: Contrast of the simulation results in traditional and projected approach in terms of cost.

Figure 10 presents the evaluation and comparison of cost factor in the traditional and the newly integrated approach of elephant herd optimization (EHO). The proposed approach is presenting the results effective in terms of less cost factor as compared to the traditional approach of LEACH.

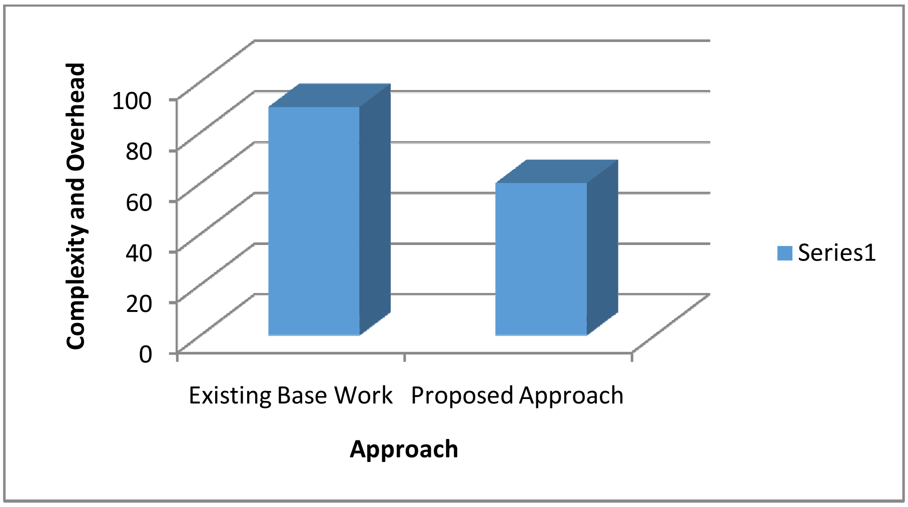

Figure 11: Contrast of the simulation results in traditional and projected approach in terms of complexity

Figure 11 presents the evaluation and comparison of complexity and overhead in the traditional and EHO based optimization. The EHO based optimization is having less complexity and overhead while executing in multiple scenarios.

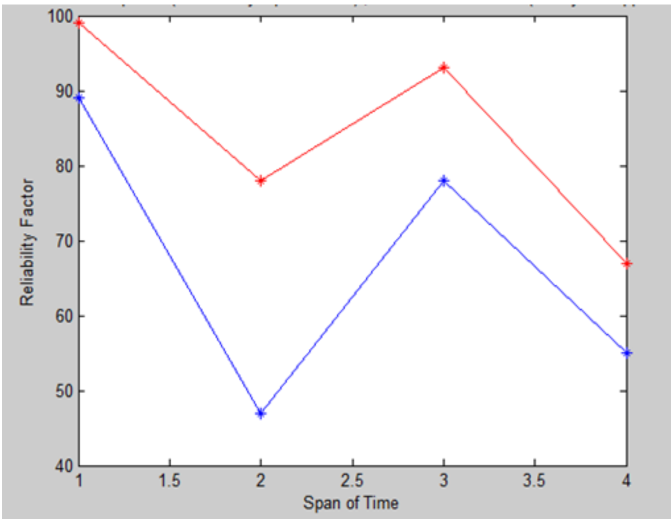

Figure 12: Evaluation of Reliability

Figure 12 presents the evaluation and comparison of reliability in the traditional with the EHO and found that the EHO based approach is better in the reliability and overall effectiveness of the network scenario with less energy decay.

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Instance with Nodes	Optimization - EHO	Traditional – Existing
3	10	2
5	14	3
10	15	11
20	19	15

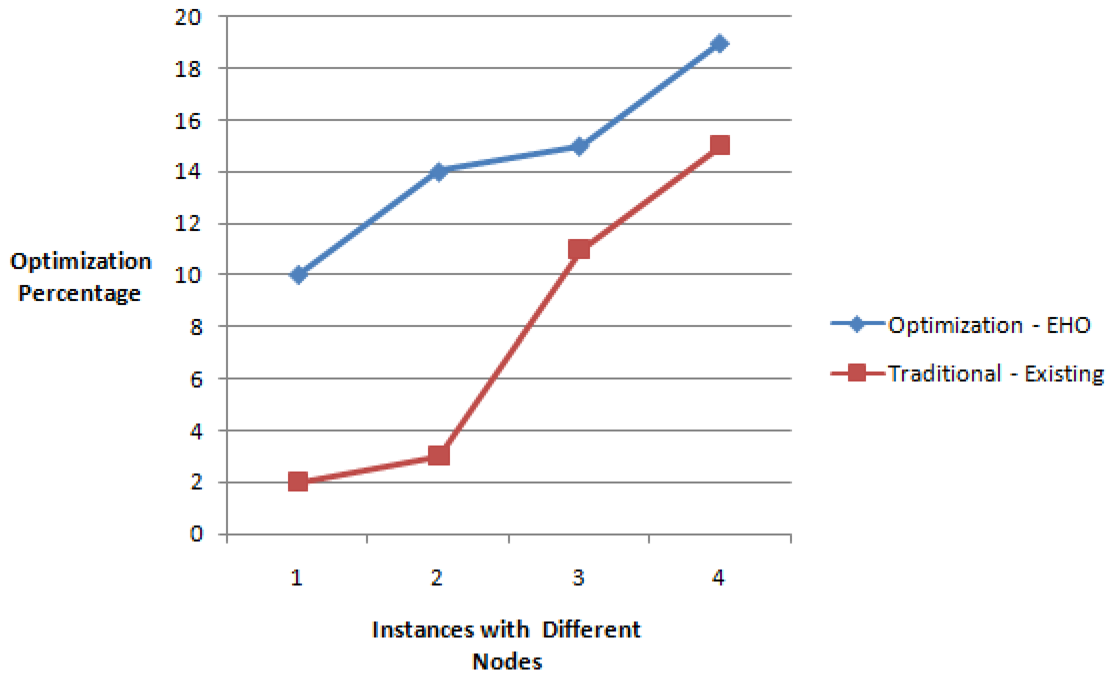

Figure 13: Evaluation of Reliability

The results depict that the optimization level in the proposed approach is effective and better than the traditional approach in huge extent.

Conclusion and Future Scope

Population based optimization approaches are quite prominent and widely used to solve the assorted combinatorial optimization problems or in the engineering optimization domain. this work is having the implementation perspectives of Elephant Herd Optimization (EHO) with the analogous aspects to cluster head formation in the underwater sensor networks so that the overall lifetime of network can be improved. The work is based on the dynamic clustering with selection of dynamic cluster head as similar to the clan of elephants. To improve this work, the integration of deep Learning can be done that is highly optimized approach with the advancements of artificial intelligence. In addition, the approaches of soft computing and nature inspired paradigms can be associated for achieving the higher degree of accuracy and optimization levels. These approaches may include river formation dynamics, bat algorithm, cuckoo search, lion optimization, flower pollination and many others.

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