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UNDERWATER ACOUSTIC SENSOR NETWORK ENERGY OPTIMIZATION USING ARTIFICIAL IMMUNE APPROACH

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Abstract- Water cover large portion of earth, hence it has many resources that need to be explored. So many of researchers work in this field from years. For continuous monitoring of some area sensor network were established. In acoustic environment working of wireless network is tough, hence energy optimization is highly required. This paper has proposed a model AIASNO (Artificial Immune Acoustic Sensor Network Optimization) that works on sensor network communication management for packet routing. For increasing the life span of network nodes were clustered by artificial immune algorithm. Experiment was done in different Acoustic environment. Results were compared with existing models and it was found that proposed AIASNO has improved the packet transfer count and life span of networks as well.
Index Terms— UWSN, Communication, Routing, Energy Optimization, Genetic Algorithm.

I. INTRODUCTION

Securing Underwater Wireless communication Networks (UWCNs) area unit deep-seated by sensors and Autonomous Underwater Vehicles (AUVs) that move to perform specific applications like underwater observance Coordination and sharing of data between sensors and AUVs create the supply of security difficult[1]. The aquatic surroundings is especially liable to malicious attacks thanks to the high bit error rates, giant and variable propagation delays, and low information measure of acoustic channels. Achieving reliable repose vehicle and sensor-AUV communication is very troublesome thanks to the quality of AUVs and therefore the movement of sensors with water currents. The distinctive characteristics of the underwater acoustic channel, and therefore the variations between underwater detector networks and their ground primarily based counterparts need the event of economical and reliable security mechanisms [2].

Underwater sensor networks nodes are not static like ground-based sensor networks nodes. Instead, they move due to different activities and circumstances of underwater environment, usually 2-3m/sec with water currents. Sensed data is meaningful only when localization is involved. Another major issue that is affecting underwater sensor networks is energy saving [3]. Because of nodes mobility, the majority of offered energy competent protocols become inappropriate for underwater sensor networks. Different protocols regarding land-based sensor networks are, for example, Directed Diffusion, Gradient, Rumor routing, TTDD, and SPIN.

However, because of mobility and rapid change in network topology these existing grounds based routing protocols cannot perform efficiently in underwater environment [4]. Optimal packet size is depending on protocol characteristic like offered load and bit error rate. Poor packet size selection decreases the performance of the network throughput efficiency, latency, and resource utilization and energy consumption in multihop underwater networks can be greatly improved by a using optimum packet size [5, 6]. To improve the better utilization of the available resources in underwater environment considering the energy and life time of network is discussed in detail in this paper. Balancing of energy consumption is carried out in underwater environment using the proposed techniques.

I. Related Work

In [7] paper offers the newest analysis on the available evidences by reviewing studies in the past five years on various aspects that support network activities and applications in AIASNO environments. This work was motivated by the need for robust and flexible solutions that can satisfy the requirements for the rapid development of the underwater wireless sensor networks. This paper identifies the key requirements for achieving essential services as well as common platforms for AIASNO. It also contributes a taxonomy of the critical elements in AIASNOs by devising a classification on architectural elements, communications, routing protocol and standards, security, and applications of AIASNOs.

A “reliable multipath energy-efficient routing protocol (RMEER)” is presented in [8]. This research work targets to enhance the network lifetime and set an optimal route to deliver the information to the desired target. The whole network is divided into five different and equal layers. The final destination node is placed at the top of the water surface, and static powerful carriers are deployed in the remaining layers. The last layer of the network contains ordinary sensor nodes. The multipath data routing mechanism is followed to deliver the information. In order to improve the packet delivery ratio multi sinks with the multipath disjoint algorithm are used. In this algorithm, if any node dies, then an alternate route selection bypasses the died node route [9]. The data forwarding process is defined by a routing table. A hello packet is sent by the courier node; after receiving this packet, every source node updates its routing table. This table contains the residual energy, link quality, and node ID. By analyzing all these parameters, an optimal forwarder node is selected for the data transmission towards the sink.

In [10], cooperation and multihop energy-efficient routing schemes are introduced for UA-WSNs. The information is generated by the nodes and directs this information towards the sinks through a multihop algorithm. To enhance the reliability of the network, a cooperation scheme is introduced to the one-hop communication. The data forwarding stage is accomplished in two phases. In the first phase, the forwarder node receives the information, and in the second phase, along with the forwarder node, one relay node is set to transmit the data. When both forwarders receive the information, then MRC technique is used which merges these two packets to make one reliable packet. To find the relative distance between nodes, the RSS algorithm is used. The outcomes of the proposed scheme show the best responses in terms of energy and stability of the network.

The fuzzy vector technique is determined in [11] which copes with the delay minimization and battery life issues. This is an advanced version in which fuzzy logic technique (FLT) is utilized. The source generates information and then directs it towards the sink through a multihop mechanism and considers the maximum residual energy for data advancement. The best forwarder selection depends on the residual energy along with the node position. When the data packet generated by the source is broadcasted, all its neighbors receive the packet. Amongst all neighbors, one optimal node is chosen to deliver data to the next node. The residual energy of the selected node should be maximum so that it does not die soon and the position of this node should be minimum to sink node. The experimental results show the best responses in terms of fast data transmission and the network have maximum alive nodes.

II. Proposed Methodology

Acoustic Wireless Network need communication system that reduces the energy uses. For this clustering of nodes plays an important role. But as water waves shift nodes position hence dynamic approach is required that not ned any guidance. This paper has developed a **AIASNO** (Artificial immune Based Acoustic Sensor Network Optimization) model to cluster Acoustic network nodes. Fig. 1 shows various steps of clustering and Table 1 list different set of notations used in this paper.

Develop AIASNO Environment

Develop an V volume under water, place N number of nodes present in the region. Relegate their starting energy level before transmitting and getting any bundles. Energy utilization per unit node is required to be evaluate [13].

The transmission energy (E_{Tx}) and accepting energy (E_{Rx}) can be processed for a packet of length L bit, d the space among source and next/base/cluster node,.

The model to estimate the minimum transmission power in underwater acoustic communication is adopted based on themodel in [19], [20]. Denote P_0 as the minimum received power to successful receive a packet. Let $U(d)$ be the attenuation of transmitting underwater acoustic signals between twonodes with the distance of d . Then, the minimum transmission power is [30]

$P = P_0 \cdot U(d)$

where

$$U(d) = (1000xd)^m[\gamma(f)]^d$$

Here, m is the environmental coefficient (where we take m D 1:5 for shallow water acoustic channels) and $\gamma(f)$ is the absorption coefficient under carrier frequency f.We often use the Thorp's formula to formulate (f), i.e.,

$$10log_{10}\gamma(f) = \frac{0.11f^2}{1+f^2} + \frac{44f^2}{4100+f^2} + 2.75 \times 10^{-4}f^2 + 0.003$$

The optimal choice of *f* is based on the empirical formula below [30]:

$$f_{opt} = \left(\frac{200}{d}\right)^{2/3}$$

If cooperative nodes participate in the DCC transmissions, the total energy consumption of a transmission is the sum of the energy consumption of node *i*, node *i* + 1, and the corresponding cooperative node. The formula for calculating the total energy consumption for transmitting a packet, denoted as *E*, is

$$E = P_o \frac{U(d_{i,i+1}) + \delta \times U(d_{c,i+1})}{1 + \delta} \times T$$

where $U(d_{i,i+1})$ and $U(d_{c,i+1})$ are the underwater sound attenuation between node *i* and node *i* + 1 and between the cooperative node and node *i* + 1, respectively, *T* is the transmission time of node *i*, and δ is a binary indicator to imply if DCC is needed, i.e.,

$$\delta = \begin{cases} 0, & d_{i,i+1} < r_{max}\ for\ non\ DCC\ cooperation \\ 1, & d_{i,i+1} > r_{max} for\ DCC\ cooperation \end{cases}$$

where r_{max} is the maximum distance between two nodes to determine if a cooperation node is needed for achieving the DCC transmission [14].

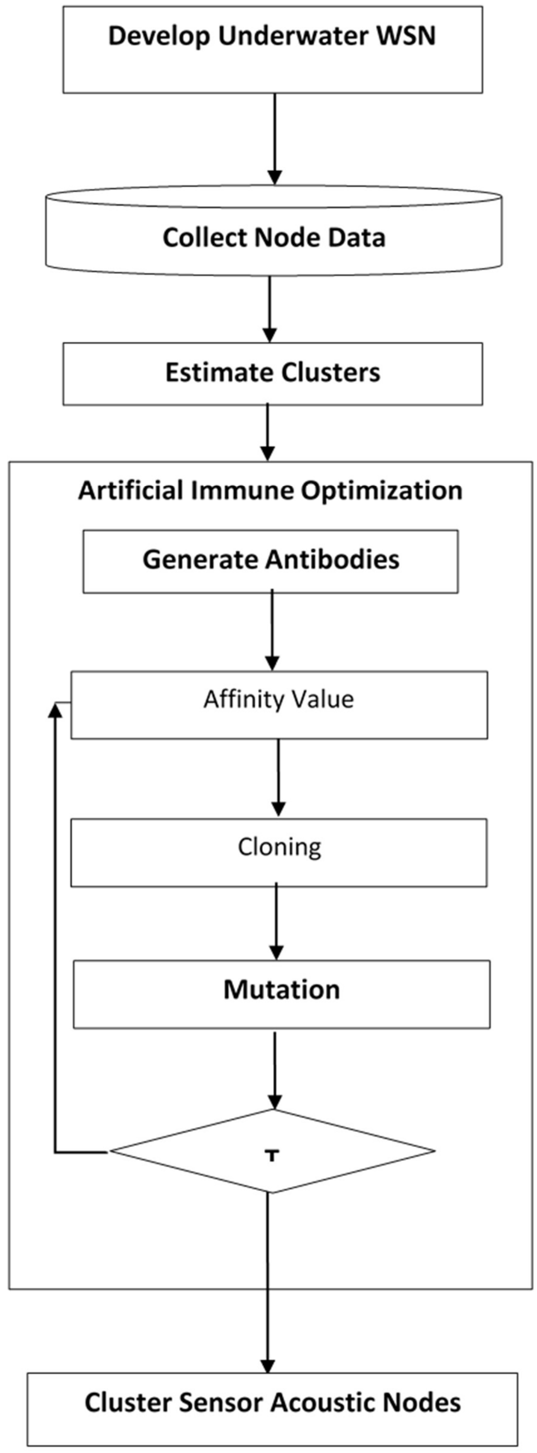

Fig. 2 Block diagram of proposed AIASNO model.

Table 1 MFUNO model notations.

Symbol	Meaning
N	Nodes
V	Volume

E	Energy
d	Distance between nodes
CN	Cluster center Node
K	Number of cluster
L	Number of bits in Packet
E	Energy need to Transfer L bits
T	Transmission time
A	Antibodies population
n	Number of antibodies in population
F	Affinity of Antibodies
Pos	Position of Node in V

Estimate K Cluster

Find number of cluster in the volume. Where r is range of nodes to transmit [7].

$$K = \frac{3M^3}{4\pi r^3}$$

Generate Antibodies

Random set of nodes were collect by Gaussian function to act as cluster center in the network. Each collected random set of nodes act as antibody. Collection of more than one antibody is population. For getting better combination work has applied node distance criteria.

A←Generate_Antibody(n)

Affinity

Affinity of antibody present in the population were estimate by sending one packet from each sensor network node to the base station by passing through the cluster center node. Fitness value is considered as the total energy cost to send one packet from each sensor node to base station, by antibodies of the population. As distance between the nodes were:

F←Affinity(A)

Cloning

As per affinity value of each antibody in population, best solution A_b is obtained. As per best antibody A_b nodes set few nodes were randomly change place in the other antibody of cloning process. By change in nodes cloning of the model is done.

A←Cloning(A_b, A)

Hypermutation

The clones are then subjected to a hyper mutation procedure, in which antibodies are mutated in inverse proportion to their affinity, with the best antibody's clones being mutated the least and the poorest antibody's clones being mutated the most. The clones and their original antibodies are then analysed, and the best N antibodies are chosen for the next iteration. It's possible for the mutation to be uniform, Gaussian, or exponential.

A←Hypermutation(A)

Update Antibody population

After t number of iterations antibodies final best node set were extract and list it as cluster center of acoustic sensor network. In case t iteration not reach then affinity operation starts again.

Proposed AIASNO Algorithm

Input: N, V

Output: ACN // Cluster nodes

1. AN ←Establish_Acoustic_Network (N, V)
2. [d K e]←Collect_Data(AN, N)
3. A←Antibodies_Population(p, K, d)
4. F←Affinity(M,N)
5. Loop 1:T
6. A←Cloning(A,F)
7. A←Hypermutation(A,F)
8. F←Affinity(M,N, d)
9. A←Update_Antibody_Population(A,F)
10. End Loop
11. F←Affinity(M,N, d)
12. ACN←Cluster_Nodes(F, N)

III. Experiment And Result

Implementation of proposed AIASNO was done on MATLAB platform. Experimental values was compared with existing model of WSN energy optimization ECRKQ [21]. Hardware setup for experimental work have configuration of 4GB RAM, Intel I3 processor.

Results

Table 2. First Node discharge round.

Acoustic Setup Nodes, Volume	ECRKQ	MFUNO	**AIASNO**
80, (200x200x200)	8	9	9

120, (200x200x200)	7	8	7
150, (200x200x200)	8	8	7
180, (200x200x200)	8	9	8
210, (200x200x200)	7	7	8

Table 2 shows the first node loss round count for acoustic environment communication models. It was found that use of genetic algorithm in MFUNO and **AIASNO** for clustering has reduces the energy losses in communication. Node signal need high energy to transfer packet as compared to free air environment, hence number of rounds are low.

Table 3 Total number of rounds.

Acoustic Setup Nodes, Volume	ECRKQ	MFUNO	**AIASNO**
80, (200x200x200)	50	58	153
120, (200x200x200)	71	88	752
150, (200x200x200)	86	558	770
180, (200x200x200)	166	286	378
210, (200x200x200)	76	352	427

Table 3 shows that proposed model has increased the Acoustic WSN network parameters values. It was found that use of artificial immune optimization for clustering the nodes works better as compared to ECRKQ model. Number of rounds was increased by 45.88% as compared to MFUNO.

Table 4. Number of packet transfer.

Acoustic Setup Nodes, Volume	ECRKQ	MFUNO	**AIASNO**

80, (200x200x200)	1144	986	1927
120, (200x200x200)	2015	2179	2408
150, (200x200x200)	2685	2953	3927
180, (200x200x200)	3472	3881	4142
210, (200x200x200)	3133	4527	6684

Table 4 shows that use of distance and energy feature for the fitness estimation of cluster center has improved the packet transfer count by 34.78% as compared to ECRKQ. Selection of nearby cluster center as node and shuffling of cluster center increase the life span of the model that directly impact the parameters in MFUNO and **AIASNO**.

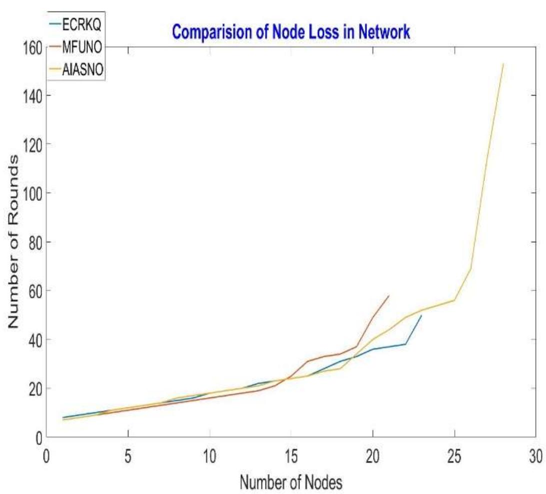

Fig. 2 Number of rounds covers during, 80 nodes losses in 200x200x200 volume of water.

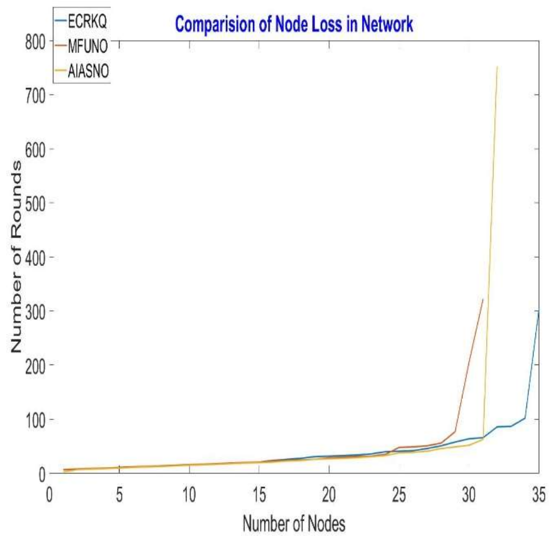

Fig. 3 Number of rounds covers during, 120 nodes losses in 200x200x200 volume of water.

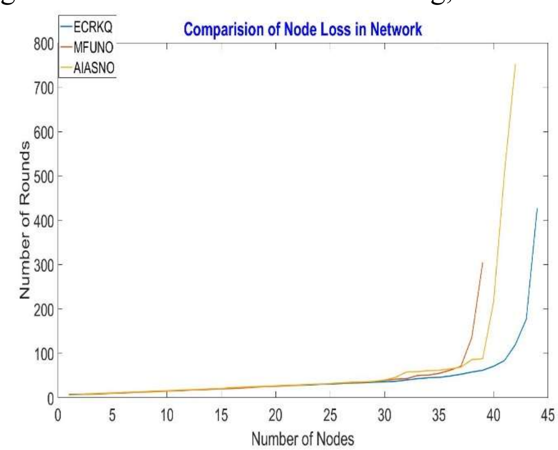

Fig. 4 Number of rounds covers during, 150 nodes losses in 200x200x200 volume of water.

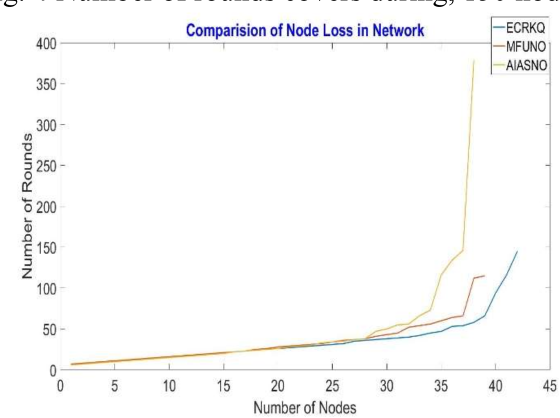

Fig. 5 Number of rounds covers during, 180 nodes losses in 200x200x200 volume of water.

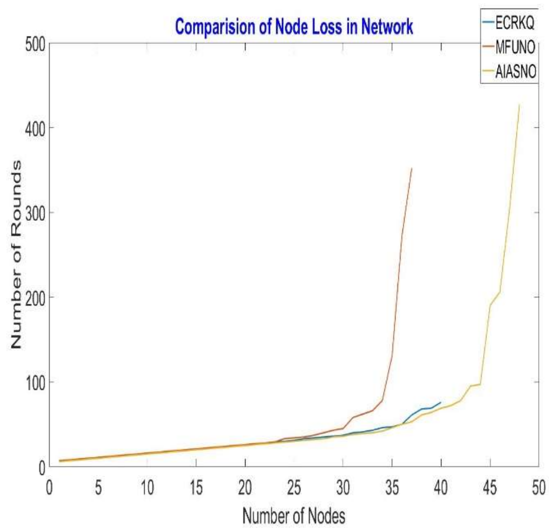

Fig. 6 Number of rounds covers during, 210 nodes losses in 200x200x200 volume of water.

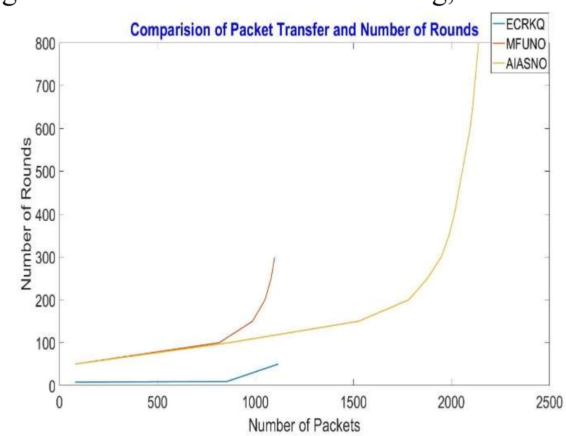

Fig. 7 Number of packets transfer under different rounds of algorithm for 80 nodes in 200x200x200 volume of water.

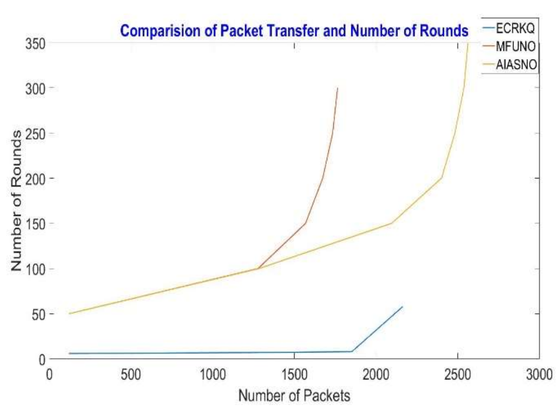

Fig. 8 Number of packets transfer under different rounds of algorithm for 120 nodes in 200x200x200 volume of water.

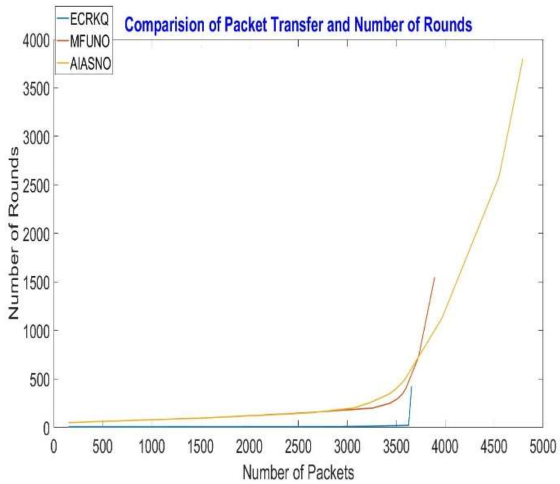

Fig. 9 Number of packets transfer under different rounds of algorithm for 150 nodes in 200x200x200 volume of water.

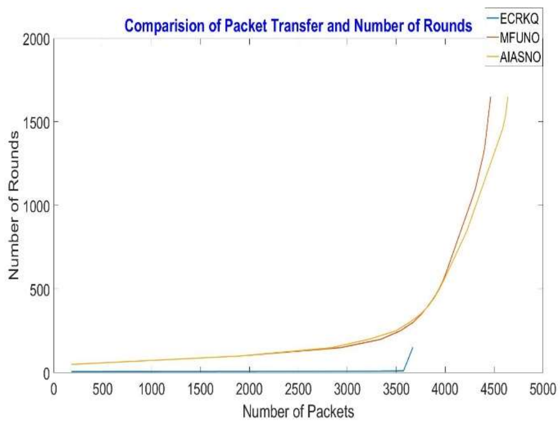

Fig. 10 Number of packets transfer under different rounds of algorithm for 180 nodes in 200x200x200 volume of water.

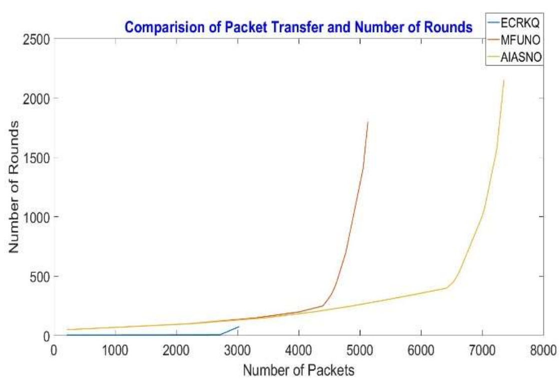

Fig. 11 Number of packets transfer under different rounds of algorithm for 210 nodes in 200x200x200 volume of water.

IV. Conclusion

The waters that make up our planet's oceans and seas are home to a large number of resources as well as information that is only accessible to a select few. It is just not possible to finish the investigation without the assistance of methods that are quite technically advanced. Unmanned vehicles and sensor systems that are able to function Acoustic are among the most important elements of the collaborative network and communication frameworks. Because of this work, the lifespan of the network has been extended thanks to an improvement in the energy utilization of the nodes. The clustering method based on artificial immune has proven to be effective in increasing work efficiency. The fitness of the cluster center was determined by taking into account the distance between nodes and their energy levels. Experiments were carried out on real datasets, and the results indicate that the suggested AIASNO has led to an improvement in the In comparison to ECRKQ, there will be a greater total number of rounds. In a similar fashion, the count of packet transfers was raised. In the future, researchers might concentrate their efforts on developing better routing systems and channel sensing techniques in order to maximize the use of available energy.

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