Lifetime Improvement Of Wireless Sensor Networks Using Sheep Behaviour Based Optimized Routing And Clustering Technique

R. K. Krishna **H. S. Pangantiwar**

Department of ECE, Rajiv Gandhi College of Engineering Research and Technology, Chandrapur 442403, India

Abstract

A new approach to clustering is proposed in this paper inspired by the herd behavior of Sheep. Sheep generally travel in flock but they tend to form subgroups. Group of sheep tend to have a leader whom the other sheep follow and in groups of sheep belonging to same breed tend to form subgroups but the flocks tend to move together. This behavior of sheep is used in the clustering process where the total number of nodes is divided into groups of eight to twelve nodes each and cluster head is selected for each group. Here four nodes are kept to act as Cluster heads and remaining four to eight nodes perform the function of collection and transfer of information to the Cluster heads. When energy of the cluster head gets used up, node with next higher energy takes over as the cluster head to improve longevity of the cluster. In this way the process is continued for all the four nodes resulting in improving the longevity of the network. Advantage of this method is that the network consisting of Sensors holds on for greater time period that is until energy in all four cluster heads is not drained. The function of the nodes is to accumulate the information and relay it to cluster heads which then transmit the data to the destination. The cluster heads nearer to the base station send the data directly whereas the cluster heads at longer distance from base station use a relay node for dispatch of information to the sink. A fitness function for relay node based on distance and energy is used. On comparison of this method with the existing techniques this method shows an improvement as this method uses lesser energy as well as sees improvement in durability of the network.

Keywords: Sheep Optimization, Flock, Subgroups, Fitness Function, Distance, Energy.

1. Introduction

The exploration in the field of sensor network has seen rapid advancements in the last few years, the reason behind this growth is evolution of wireless nodes as a repertoire of vast collection of information that can be shared with the world. Wireless sensor nodes are miniature devices that are spread throughout in the areas not accessible by human beings whose primary duty is to collect the data of different parameters such as temperature, pressure, humidity and other conditions that may be useful to base stations where they are analysed. These nodes consist of batteries that recharged cannot be charged again once they are placed in their positions. Therefore, many researchers are concentrating on improving or increasing the lifetime of these batteries so as to increase the duration of the working of the network. Use of the wireless network in an optimum manner by using the sensor nodes when necessary and also making them sleep in between are some other methods by which the lifetime of wireless sensor networks may be increased.Recently, newer methods are being explored and recommended with the goal of enhancing the life span of WSNs.The different propositions for reduction of energy consumption include energy efficient intelligent node placement and improvised clustering and routing methods.

Currently most of technologists have turned their attention and concentration on developing solutions that are motivated by swarm behaviour. Newer approaches are dellivering optimum results. Nature is also playing its role in resoving complex problems in wireless sensors networks. Animal behaviour when scrutinised shows that herd behaviour of the animals. In most of the animals such as lions, monkeys and deer, and sheep there is always one dominating animals and others follow them.

There is another group of species that include sheep, horses and fishes and some birds which do without a leader and their movement in an environment with no leader. These species are ignorant of the environment and whatever movement they carry out is on the knowledge they gain by understanding the surroundings. The popularity of these methods are growing immensely because they have only a few sets

of rules to be followed and they are providing satisfactory solutions to many difficult and complicated problems. This has resulted in establishment of energy efficient sensor networks that are lasting for longer spans.

2. Related Work

In paper 1, the authors propose a method by combining two methods, the first one being brainstorm optimization with levy distribution (BSO-LD).In this process four different parameters that include energy in the network,load of the network,,stretch to the base station and space between neghnour nodes are considered while defining the fitness function.This method is used for choosing of Cluster heads during clustering.For routing purpose a second method called water wave optimization with hill-climbing (WWO-HC) has been utilised. Initially scattering of the nodes is done arbitrarily in the region and then the information regarding nodes that are neighbouring to each other is collected. Firstly optimal number of clusterheads required in the process is determined using BSO-LD method. The next step consists of selection of optimal routes through which data may be transmitted.This is done using the WWO-HC algorithm. For finding the optimal number of routes, the process consists of finding the sizes of existingl water wavers that equal the number of CHs and an additional location is determined in the Base station. This is done to locate the ideal number ofl routes from the CHs to BS by determining the fitness function based on four different parameters that include energy, network load, stretch to the base station and space between neghnour nodes

According to authors of Paper 2 one of the most critical issues that needs consideration while considering the patterning of sensor networking is energy efficiency. During the processes concerned with WSNs, the process of communication consumes maximum energy and hence a solution to energy comservation is possible if one can reduce energy consumption during the process of communication.This can be taken care of either with the help of an efficient routing technique.Hierarchical clustering algorithms provide for viable solutions to this issue.In this approach,the author's breakup the nodes into few groupings so that there is no need for long distance communication. A fresh approach to clustering is proposed wherein cluster heads are chosen influenced by the grey wolf optimizer (GWO).This method is seen to give very good results and is motivated by the herd behaviour of grey wolves.TheCHs are chosen on the basis of forecast of consumption of energy as well as existing balance in every node.With a purpose of enhancing the efiiciency in energy ,this method employs the already used clustering technique repeatedly for multiple succeessding rounds.The result is that lot of energy is saved and this preserved energy can be utilised for reformation of clustering. Also for CHs that are far away from the destination, a different approach called the dual hop routing algorithm is recommended.This approach makes sure that there is a balanced energy consumption througout the process of communication.

In paper 3, the authors combine two very popular approches called PEGASIS or Power Efficient gathering in Sensor information systems and the Dragonfly Algorithm and make further improvements resulting in a effective algorithm that makes for an adequately efficient system that consumes lesser energy and while doing so selects an optimal chain for routing to base station. For the node ditribution phase the authors propose methods influenced by three approaches that include the random metgod,the firefly algorithm and the control approach which results in preservation of large amount of energy presumimg that base station is static.In the suggested approach,the authors separate the region into five parts as per the given method so that the load of relaying information is decreased and this results in reduction in cost of communication .This method has been aptly named as (PEG-DA)Pegasis protocol and Dragonfly algorithm.Three methods are envisaged for distribution of nodes in the above approach.The first one being random approach, the second one being firefly algorithm and the third one is the control method of distribution.Once distributed the nodes have an equal energy and these nodes also separate unique ID. All the nodes positions are already established and monitored by GPS. All nodes take part in data transfer process.

Paper 4 intends to study and evaluate the performance of WSNs using different Bioinspired Optimization techniques. In this technique for increasing the period of work of wireless sensor networks, a method of balancing of load of cluster heads is proposed. The methods that have been explored in these papers include different bio inspired optimization methods that include GA, PSO and BFO. Also new methods by

combining GA method and PSO method have been proposed.Otimising Quality of service is also an important issue.To overcome this issue, a CH algorithm is proposed so as to select an efficient CH and in doing so there is an increase in the overhead the CH.This results in increase in the load of cluster head resulting in more consumption of energy. Therefore, it is necessary to introduce the technology of balancing of load so that overall energy consumption is reduced. The next process after cluster formation is routing. Selection of a route that is ideal in terms of distance and energy saves a lot of energy. For the process of finding a proper route many optimization techniques based on GA, PSO and BFO have been put forward for decreasing the time required for transmission of data from source to base station. For this purpose, a fitness function is defined which is used for selection of fittest paternal chromosomes. When the duration is more than the threshold then only BFO method is recommended .Only when there is sufficient time duration and also energy is in excess, this method is preferred. The algorithm is a combination of Genetic and PSO.The method is designed in such a way that the prelimany route is found out using the Genetic algorithm and optimization is achieved using the PSO algorithm.

In Paper 5, the authors have put forward a process which takes on the important problem of energy consumption of networks and methods to reduce this consumption of energy and keep it to minimum so that the life of a sensor network should increase substantially. For this purpose the authors have attempted a new approch making use of the salient features of bioinspired as well as artificial intelligence algorithms.Whenever any information is to be relayed or received, any error in distance or range irrespective of nodes whether in range or not cause a loss in packets.This may impact the routing to an extent.Particle swarm optimisation technique is utilised for communication of data efficiently because this method uses iterations for updation and hence are able to help in establishment of optimal coordinate points for communication process.Also the amount of energy consumption for every node is computed that takes into considerations different variables such as count of agents and neighbours and span to the sink are taken into account for training in neural networks and at last a forecast is secured which aids in node status estimation .This estimation helps in deciding whether it can be utilised for furthers iterations.These forecasts that are computed on the basis of energy consumption and energy requirement estimation for transfer of information for each node. In this paper the authors have used PSO for routing estimation and finding the distance error between nodes.In the second phase they have used neural networks technology for determining the node status as well as deciding whether the node can be utilised for further processing or should be rejected from the path to the destination used for transfer of data.

3. Proposed Work

The energy model for energy and lifetime computation as proposed by Yuan Zhou, Ning Wang, and Wei Xiang (2017) has been used.It is made up of a transmitter and a receiver. It is assumed that there are N sensor nodes that are used to keep track of the environment.

Let energy consumed in transmitter electronics be E_{tx} and energy consumed in receiver electronics is E_{rx} and energy consumed in transmitter amplifier is E_{amp}. Let'd' be the span connecting transmitter to the eceiver which determines the use of either free space model or multipath model. If the span is smaller than a threshold 'dt' ,generally free space model with a power loss of $d^2$is preferred and if the span is greater than the threshold 'dt',a multipath model is assumed where there is a power loss of d^4.

The required energy for transmission of a packet that has l bitsfor a distance d is given as

$$E_{tx(l,d)} = \begin{cases} l \times E_{elec} + l \times E_{fs} \times d^2 if d \leq d_t \\ l \times E_{elec} + l \times E_{mp} \times d^4 if d > d_t \end{cases} \quad (1)$$

Here 'Eelec' is the energy dissipated per bit to transmitter and receiver circuit, 'Efs' and 'Emp' are energies used for reception for free space and multipath respectively, and 'l' is the length of data transmitted and 'dt' is the distance threshold and is described by the equation

$$d_t = \sqrt{\frac{Efs}{Emp}} \quad (2)$$

Energy consumption for reception of *l* bit energy is given as

$$E_{rx}(l) = l \times E_{elec} \quad (3)$$

In many applications the networks continue to function even when a few nodes die. This is because other nodes replace the dead nodes and perform their functions. Therefore, we may define Lifetime as the time till a fraction of alive nodes that are alive decreases below a threshold that has been decided earlier.

Therefore, Lifetime of a Network is expressed as

$$LT_N^a = LT[\ \Delta = \frac{a}{N}\ ] \quad (4)$$

Where a=number of alive nodes and N= total number of nodes.

It is presumed that the count of clusters is 'n', and the nodes in each cluster are 'm'. The forwarded algorithm presumes four cluster heads. Therefore, the count of sensor nodes in every cluster is (m-4) that is leaving out the cluster heads.

Energy used up by the a sensor node for sending of data and receiving of data and reception in addition to time to time sleep phases can be computed as follows:

$$E_{sn} = (1 - ps)[E_{tx}(l, d) + E_{rx}(l)] + p_s E_s \quad (5)$$

Where p_s is the sleep probability and E_s is the energy utilised during the period when the node sleeps.

The information that is accumulated by the Cluster Head is then transmitted to the Cluster head that is close to the sink or directly to the destination. The decision of using free space model or multipath to be used is based on the stretch between the cluster head and base station.

Hence energy dissipated by the Cluster head is

$$E_{ch} = E_{tx}(l, d) + (m - 4)E_{rx}(l) + ml(E_{da}) \quad (6)$$

where m is the count of sensor nodes that are present in a cluster.

E_{da} is the energy dissipated per bit because of the process of collection of data.

Therefore, dissipation of energy in a cluster is given as

$$E_{Cluster} = E_{ch} + mE_{sn} \quad (7)$$

Therefore, total Energy consumed is given as

$$E_{total} = E_{Cluster} \times n. \quad (8)$$

Where n is the number of Clusters.

4. Proposed Methodology

Sheep are also flock animals that move in groups. There is definitely a dominance hierarchy in Sheep and they always follow a leader. All sheep generally gather near the other members of the Flock. During Flocking, Sheep generally tend to follow the leader who takes the first step. Sheep that are related to each other have a close relationship. Generally, sheep that belong to the same breed form subgroups and larger groups that are later on formed are also related to each other or their descendants. They then move in such large flocks so formed. Dominance is maintained using the methods of fighting, intimidation and competitions.

This property of sheep is the basis of the proposed optimization technique for a wireless sensor network. By assuming that there are about 100 sheep in an area and they form 8 to 10 groups each consisting of eight to twelve nodes. Therefore, in an area of 300m×300m, we assume that about 100 nodes analogous to 100 sheep are randomly spread out. Then cluster formation takes place with 8 to 12 nodes in every cluster. These clusters are formed by drawing 10 circles and node falling in that particular circle will form one group. Therefore, we may say that the number of nodes in each group will be non-uniform with some groups having lesser nodes and some having more nodes. Of these nodes four nodes are reserved to act as cluster heads though they may also participate in data collection except the node that acts as Clusterhead.Each of these four nodes will act as Cluster heads one after the other after exhaustion of their energies. Once the process of formation of clusters is done with, the process continues and the node that has extreme energy is picked up as the CH. The other nodes now collect the data and forward it to the cluster head who then forward the data to the destination or the sink. After a few rounds of communication is completed the Cluster head exhausts all its energy and will not be able to participate in the communication process. Then the cluster head with second extreme energy takes over and the transmission of energy takes place through this clusterhead. Data is collected by the nodes and sent to the new cluster head and data transmission to the destination continues. If the span from cluster head to Base station is more than a threshold then data is transmitted through a relay node. A fitness function is defined for the

selection of the relay nodes. Relay nodes are generally selected in such a way that the node equidistant between CH and Sink and the node with higher energy if there is more than one node in the vicinity is selected. The base station is presumed to be established at the centre.

The method put forward is composed of the of the following steps

a) A total of 100 nodes are distributed in a random manner over a area that is square in size with dimensions of 300m×300m.
b) These nodes are allocated energies non uniformly.
c) The sink is established at the centre of the clusters.
d) The next step is formation of 10 clusters.Every cluster is composed of 8 to 12 nodes.
e) Each cluster is allocated a number starting from 1 till 10.
f) Next step is noting down the energies of all nodes.
g) Extreme energy node in every cluster is named the Cluster head.
h) Then information is gathered by every node and then relayed to the respective Cluster heads.
i) The cluster headsthen forward the gathered information to the destination that is the BS.
j) If the separation between the CH and BS is greater than a predefined threshold then it is necessary that an intermediate node be used for helping the data transfer from source to destination.
k) As is known at the end of one round of communication, the energies of cluster heads will reduce as lot of energy is used up for data transfer process, and naturally energy of some other node may become more than the cluster head.
l) Now the node with extreme energy now shall act as the Cluster head.
m) Again, communications take place for few rounds. Energies of nodes after every round are computed.
n) After energy of the present cluster head crosses its threshold, the node with the maximum energy will assume the role of Cluster head and process continues.
o) In this way the communication continues until four cluster heads do not exhaust their energy.
p) After cluster the process of Routing needs to be For Routing has to be completed. The source node is first determined. Base station is considered as the destination node.
q) Distance Between source node and destination node is computed.
r) If distance is more than threshold, intermediate node is to be selected.
s) Next a square area that lies in middle ie. linking the source node and destination node is determined
t) The energy of nodes in this area is computed
u) For selection of intermediate node the criterion is maximum energy.
v) Data is transmitted through this node.

By the time the four Cluster heads exhaust their energies one after the other many numbers of communications would have taken place and many numbers of nodes also have their energy depleted and communication ends when 90% of nodes die.

5. Results Analysis

The method put forward has been implemented in NS2 scenario. The mode presumed is the two-ray ground propagation model. CBR of always on type pattern is assumed. A threshold of 0.2mj is defined. The parameters considered are number of nodes that are alive, energy used during transmission and lifetime are chronicled and compared.

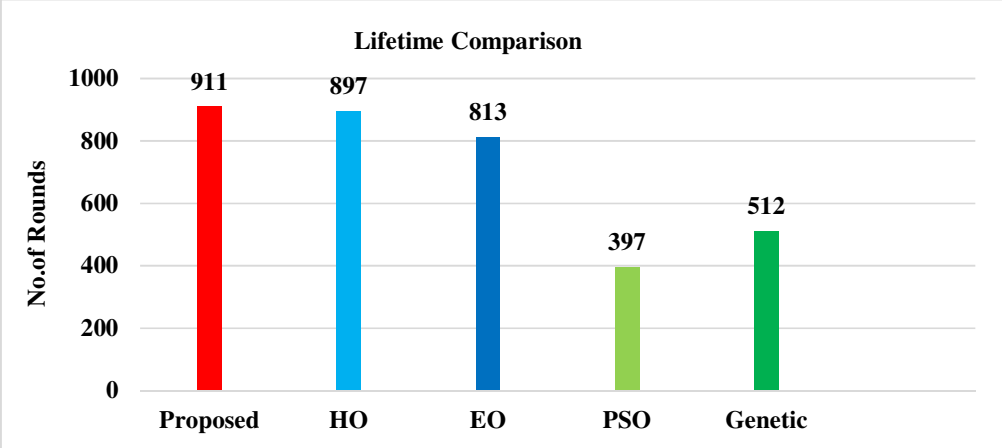

Fig 1 Lifetime Comparison of different techniques.

Fig.1 indicates how the proposed technique is better than the existing techniques that can be compared that include the other Bio inspired techniques HO, EHO, PSO and Genetic techniques. The proposed method with 911 rounds runs for more time and hence is a better method.

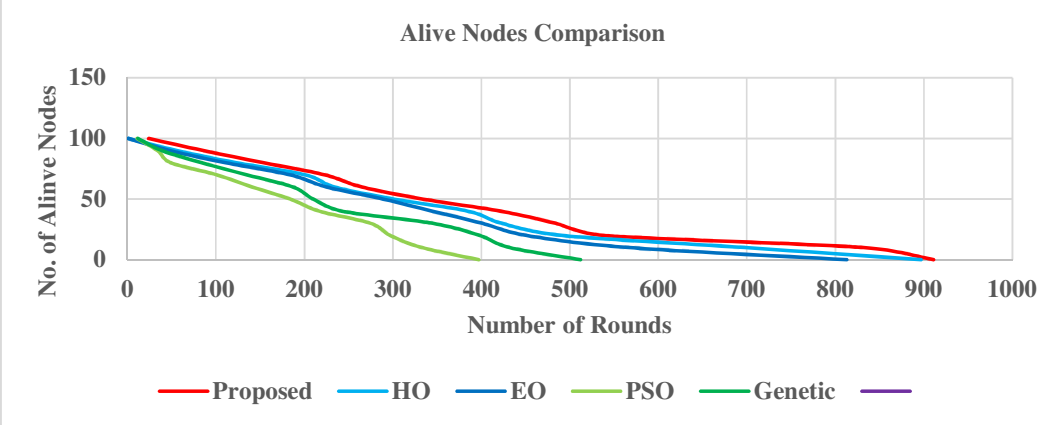

Fig. 2 number of alive nodes.

Fig.2 indicates how the forwarded method is more efficient in terms of number of alive nodes. Observation shows that nodes of the forwarded method are alive for a greater duration and hence can be said to be a more efficient method.

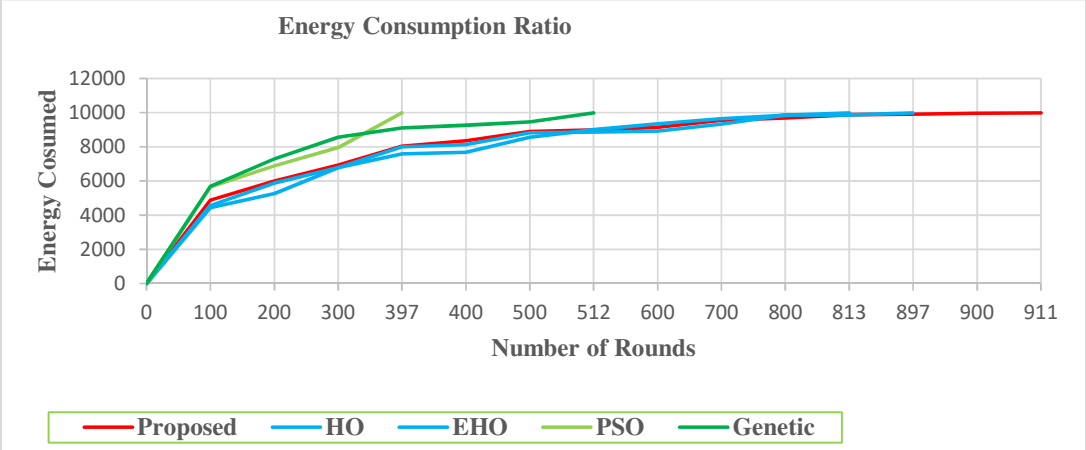

Fig.3 graph showing the energy consumption of the different methods

Graph indicates that the proposed process consumes lesser amount of energy. Therefore this method is more efficient than the other comparable methods.

6. Conclusions

We have put forward a process which is motivated by the herd behaviour of Sheep. Here clustering is implemented using circles method and or routing a fitness function is developed which is based on two factors one being distance and other being energy. This new clustering and routing method ahs been compared with the other contemporary techniques and the method proposed keeps the network working for a longer duration.

References

1 Shaha al-Otaibi, Amal al-Rasheed, Romany F. Mansour, Eunmok Yang, Gyanendra Prasad Joshi, and Woong Cho, “Hybridization of Metaheuristic Algorithm forDynamic Cluster-Based Routing Protocolin Wireless Sensor Networks ”, IEEEAcess, Volume 9, 2021, pp.83751-83761.

2 S.M.Mahdi, H.Daneshvar, PardisAlikhahAhariMohajerandSayyedMajidMazinani,“Energy-Efficient Routing in WSN: A Centralized Cluster-Based Approach via GreyWolfOptimizer”,IEEEAcess, Volume 7, 2019, pp.170019 -170031.

3 Shifaa I. Abdulhameed, Salah A. Aliesawi, “Dragonfly Algorithm for Enhancing PEGASIS Protocols in Wireless Sensor Networks”, 2nd Annual International Conference on Information and Sciences (AiCIS) University of Anbar, Anbar, Iraq, 2020,pp106-113.

4 Mandeep Kaur and Balwinder Singh Sohi, “Comparative Analysis of Bio Inspired Optimization Techniques in Wireless Sensor Networks with GAPSO Approach”, Indian Journal of Science and Technology, Vol 11 (4), January 2017, pp 1-10.

5 Manoj Challa , M .Damodar Reddy,P.Venkata Subba Reddy, “Energy Aware WSN Transmission and Network Lifetime Improvement using Particle Swarm based Distance Error Optimization”,International Journal of Applied Engineering Research,Volume 13, Number 11 (2018) pp. 9218-9227.

6 Soumitra Das, S. Barani, Sanjeev Wagh and S.S. Sonavane, “An Exhaustive Survey On Nature Inspired Metaheuristic Algorithms For Energy Optimization In Wireless Sensor Network”,Ictact Journal on Communication Technology, Volume: 06, Issue: 04 , December 2015, pp.1173-81.

7 Yuan Zhou, Ning Wang, and Wei Xiang, “Clustering Hierarchy Protocol in Wireless Sensor Networks Using an Improved PSO Algorithm”, DOI 10.1109/ACCESS.2016.2633826, IEEE Access, 2017.pp1-12.

8 R. K. Krishna and B. Seetha Ramanjaneyulu, "A Strategic Node Placement and Communication Method for Energy Efficient Wireless Sensor Network", *Proceedings of 2nd International Conference on Micro-Electronics Electromagnetics and Telecommunications*, 2018.

9 R. K. Krishna and B. Seetha Ramanjaneyulu, " A EHO based Clustering and Routing technique for Lifetime enhancement of wireless sensor networks ", *Proceedings of 3rd International Conference on Micro-Electronics Electro magnetics and Telecommunications*, 2018.

10 R.K. Krishna, B. Seetha Ramanjaneyulu "Horse Optimization Based Clustering and Routing Technique for Lifetime Enhancement of Wireless Sensor Networks" Neuroquantology Journal, Volume 20, ISSUE 10, August 2022, pp. 5650-5655(Scopus Indexed).

11 K. R. Bhakare, R. K. Krishna and S. Bhakare, "Distance distribution approach of minimizing energy consumption in grid wireless sensor network", *International Journal of Engineering and Advanced Technology*, vol. 1, no. 5, pp. 375-380, 2012

12 Lodhi, Amairullah Khan, M. S. S. Rukmini, Syed Abdulsattar, and ShaikhZebaTabassum. "Performance improvement in wireless sensor networks by removing the packet drop from the node buffer." Materials Today: Proceedings 26 (2020): 2226-2230.

13 Lodhi, Amairullah Khan, and Syed Abdul Sattar. "Cluster head selection by optimized ability to restrict packet drop in wireless sensor networks."In Soft Computing in Data Analytics, pp. 453-461.Springer, Singapore, 2019.

14 Rukmini, M. S. S., and Amairullah Khan Lodhi. "Network lifetime enhancement in WSN using energy and buffer residual status with efficient mobile sink location placement." Solid State Technology 63, no. 4 (2020): 1329-1345.

15 Mohammad, Arshad Ahmad Khan, Amairullah Khan Lodhi, Abdul Bari, And Mohammed Ali Hussain. "Efficient Mobile Sink Location Placement By Residual Status In Wsn To Enhance The Network Lifetime" Journal of Engineering Science and Technology 16, no. 6 (2021): 4779-4790.

16 Tabassum, ShaikhZeba, Amairullah Khan Lodhi, M. S. S. Rukmini, and Syed Abdulsattar. "Lifetime and performance enhancement in WSN by energy-buffer residual status of nodes and the multiple mobile sink." TEST Engineering and Management 82 (2020): 3835-3845.

17 Lodhi, Amairullah Khan, M. S. S. Rukmini, and S. Abdulsattar. "Energy-efficient routing protocol for node lifetime enhancement in wireless sensor networks." Int J Adv Trends ComputSciEng 8, no. 1.3 (2019): 24-28.

18 Lodhi, Amairullah Khan, Mazher Khan, Mohammed Abdul Matheen, ShaikhAyaz Pasha, and ShaikhZebaTabassum. "Energy-Aware Architecture of Reactive Routing in WSNs Based on Mathematical Statistician and Engineering Applications ISSN: 2094-0343 2326-9865 442 Vol. 72 No. 1 (2023) http://philstat.org.ph

19 Lodhi, Amairullah Khan, M. S. S. Rukmini, and Syed Abdulsattar. "Energy-efficient routing protocol based on mobile sink node in wireless sensor networks." International Journal of Innovative Technology and Exploring Engineering (IJITEE) ISSN (2019): 2278-3075

20 Lodhi, Amairullah K., M. Santhi S. Rukmini, and Syed Abdulsattar. "Energy-efficient routing protocol for network life enhancement in wireless sensor networks." Recent Advances in Computer Science and Communications (Formerly: Recent Patents on Computer Science) 14, no. 3 (2021): 864-873.

21 Lodhi, Amairullah Khan, M. S. S. Rukmini, and Syed Abdulsattar. "Efficient energy routing protocol based on energy & buffer residual status (EBRS) for wireless sensor networks." International Journal of Engineering and Advanced Technology (IJEAT) ISSN: 2249-8958.

22 ShaikhZebaTabassumAmairullah Khan Lodhi, M S SRukmini, Syed Abdulsattar "Design Technique for Head Selection in WSNs to Enhance the Network Performance Based on Nodes Residual Status: an Extension to EBRS Method" Publication date, 2020, Journal, International Journal of Advanced Science and Technology (IJAST), Volume: 29, Issue: 5, Pages: 3562-3575, Publisher, ELSEVIER.

23 Syed AbdulsattarMazher Khan, Amairullah Khan Lodhi, SayyadAjij, M.S.S Rukmini "A Feasible Model for a Smart Transportation System using a Vehicular Ad-Hoc Network" Publication date, 2020/4/7, Journal, TEST Engineering & Management, Volume: 83, Issue March-April 2020, Pages 7341-7348, Publisher, The Mattingley Publishing Co., Inc.

24 Rukmini, M. S. S., and Amairullah Khan Lodhi. "Network lifetime enhancement in WSN using energy and buffer residual status with efficient mobile sink location placement." Solid State Technology 63, no. 4 (2020): 1329-1345.