RESEARCH PAPER

Goat Optimization Technique based on Clustering and Routing for Lifetime Enhancement in Wireless Sensor Networks

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Abstract— *In this paper Clustering is executed utilizing a new approach influenced by the herd behavior of Goat. Goats are social animals that form small groups of about 5 to 8 goats that are a family. Goats generally establish a "pecking order" or in herds there is a predominant pattern where a particular goat dominates others. Superiority is decided based on three factors: age, sex and the absence or presence of horns Once the hierarchy is established, two individual goats take up the responsibility of the whole herds become responsible for the flock's wellbeing. The buck that dominates most is called the "Top Buck". Most dominant doe is called the "Flock Queen." This behaviour of goats is the motivating factor for the proposed clustering technique. where it is presumed that 100 nodes are scattered in an area whose energies vary randomly. About 15 groups are formed with each group comprising of about 6 to 8 nodes in each group. In each group two nodes are picked to act as Cluster heads akin to Top buck and Flock Queen. The nodes collect the data and transfer it to cluster head. The cluster heads transmit the data to the sink directly and in case distance of base station is more an intermediate node will be selected. After some time of communication, the energy of cluster head is exhausted and reaches a threshold and next cluster head takes over and communication continues This process continues till the energy of second cluster head is also exhausted. On comparison of this technique with the existing techniques, this method shows an improvement in lifetime and energy consumption.***

Keywords*— Goat Optimization, Cluster heads, Top Buck, Flock Queen, Intermediate nodes, Base Station***ses**

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I. INTRODUCTION

The growth in the arena of wireless sensor networks has seen an unprecedented progress which is helping the world of communication in sharing a lot of data across the world. As is known the nodes are minute devices that can be distributed in regions that are least accessible to human beings and from these regions data of different atmospheric parameters can be collected and transmitted to base stations where these data is analyzed. One of the drawbacks of sensor nodes is that these nodes work on batteries which have been initially charged and once these nodes have taken their place they cannot be recharged. Therefore, most of the technologists are working on third aspect and most of the research is concentrated on increasing the lifetime of these batteries which in turn will increase the lifespan of the sensor meshes. For attaining these tasks, the various methods that are being explored include experiments with strategic and intelligent placement of nodes, improving the clustering methods and also the routing techniques using for transfer of information with the single goal of increasing the lifespan of wireless sensor networks.

Presently most of the technologists are exploring solutions that can be obtained based on the swarm based or bioinspired techniques. As is known that nature has an important part in providing solutions to complex problems in the field of sensor networks. Analysis of Animal behavior such as those of lions, monkey's deer, chimpanzees etc. shows that they travel in groups and naturally convey messages which can be compared to transmission of information in sensor networks utilizing clustering and routing techniques in wireless sensor networks. These groups have a leader or one of them dominates the others which inspires us in choosing cluster heads in wireless sensor networks. Also, there are another set of species such as sheep, horses and fishes and some birds which travel through environment without a leader. These travel through the knowledge of the surrounding and have provided immensely successful solutions to many a problem in wireless sensor networks. But these bioinspired methods are becoming very popular and are being implemented rapidly in high numbers, the primary reason being that there are a few sets of rules to be followed in

these techniques and they are able to provide optimum solutions to many a complex problem in wireless sensor networks.

II. RELATED WORK

Nowadays, the trend in research in the field of sensor networks is basically inspired by the animal behaviour also called bioinspired techniques. In paper [1], the authors have in a exhaustive manner investigated the available bioinspired techniques with a special concentration on present trends and present challenges. Various techniques based on mammal behavior such as ant colony, bee honey colony, bird flocks, bats, and fireflies has been thoroughly discussed. Also, Genetic Algorithm, immune systems, bacteria, or artificial plant optimization algorithm have also been analyzed. According to the authors most of the methods used in routing techniques with the purpose of improving the lifetime of wireless sensor networks ,75% of the methods are inspired by animal behaviour and only 25% based on the behaviour of plants.

The authors have discussed the different methods based on the behaviour of ants, honeybees, Fishes, bats, fireflies, monkeys, spiders' termites and elephants.Also, the authors have investigated some hybrid algorithms that have been derived using a combination of two or more different techniques. Amalgamation of fish behaviour method and swarm optimization method has also been analysed in the paper. Merger PSO with Voronoi diagram and ACO and GA have been thoroughly studied and concluded that the combination of these methods results in a more impactive method that is more efficient and effective. Methods that use Genetic algorithms have also been discussed.

In paper [2], the authors in a comprehensive manner analysed and studied the various metaheuristic techniques that are in vogue which are being used by scientists to attain efficient solutions for various issues in the field of sensor networks. The authors have proposed optimum solutions to these problems by analysing the suitability of various algorithms that are available and which may apply to various problems based on the requirement and suitability. On doing a comprehensive study, the authors conclude that there may be different ways of encoding to be done for arrival of solutions and differing operators may be required to be used for different metaheuristics and ways and means to apply these methods have been proposed. The different lifetime problems that have been discussed in this paper include Number of Alive Nodes problem, Cluster Head Election Problem, Deployment Coverage Problem, Set-Cover Problem, Data Routing problems and the different swarm-based algorithms. In this paper issues such as how to set parameters, how to represent them, and ways to measure computation cost and convergence have been described in details.

The main task in paper 3 is to comprehensively determine an effective technique that shall select a Cluster head that swaps position with another cluster head on the basis of various parameters that include initialenergy as well as residual energy and also optimum value of CHs which can be used to select the next group of CHs for networks. Basically, this paper studies how the sensor networks can be used in IOT applications. This paper puts forward two stages of operation the first one being setup stage and second one is called steady state stage. The process consists of formation of clusters and second stage constitutes selection of Cluster head. During the relay of data all the redundant bits are deleted which shall reduce the volume of data without any change in information so that speed of transmission increases. Leach algorithm is the basis of choosing the Cluster head. During communication there is energy expenditure that may be different for different nodes based on the workload of each node. The methodology consists of selection of cluster heads which the send a message to the nodes to join a particular cluster and nodes then reply and join the Cluster heads that they have to join. Then a TDMA schedule is determined and transmitted that is followed with a purpose of avoidance of collision. This procedure is carried out till the whole energy is exhausted. During relay of data another technique for saving energy is to keep only the transmitting nodes alive and put the other nodes into sleep mode. After the process of data transmission is

completed that the process of removal of redundant data takes place and then data is relayed. This helps in efficient application and utilization of bandwidth.

Paper 4 amalgamates two very efficient techniques for a routing technique. The proposed technique combines an optimization technique based on brainstorming with clustering method derived from levy distribution. The resulting method has been named as hybridization of metaheuristic cluster-based Routing (HMBCR) for WSNs and used for clustering process. For routing the proposed method derives a fitness function which is derived considering the following parameters. a) distance from base station) distance between neighbours and c) residual energy. The process of routing is accomplished using a combination of two techniques, the first one being water wave optimization and the second one called as hill-climbing (WWO-HC) technique. This is a innovative approach that is used frequently. The HC effect present in the WWO algorithm adds to the advantage of optimal search to optimize local search capability. The main goal is to find the best routes from source to sink and then find the optimum path based on two parameters that are energy and distance. In case of presence of relay node when distance between sink and source is more than a fixed threshold, the data is forwarded using this relay node. The procedure consists of primarily scattering of nodes arbitrarily ina target area. Then the BSO-LD method is implemented to choose a group of cluster heads followed by relay of data using various inter cluster paths which are decided using the WWO-HC algorithm.

The primary aim of the proposed method in paper 5 is to improve two factors the first being network longevity and the other one being network throughput. This technique utilizes anenergy harvesting model that improves the nodes lifespan as well as network lifespan. The proposed method envisages a novel method for selection of cluster head and routing model based on energy harvesting for which the propose a combination of two methods resulting in unique method which has been named Modified Leach Ant Colony Optimization (MLACO). The method enhances both network lifespan and network throughput. Also, on comparing this method with existing comparable techniques, the forwarded improves substantiallyabove the existing systems. Moreover, the method has an improved throughput with it being 31.5% above the MLEACH and 26.6% above the FEEDC method of cluster selection.

III. PROPOSED METHODOLOGY

The proposed technique draws inspiration from the herd behaviour of the goats. It is a known fact that goats form a group of 5 to 8 goats that are a part of a family. These goats have an established pattern of creating a pecking order wherein one of the goats has higher dominance or is a dominant member of the family. Depending on the different factors such as age, sex and absence or presence of horns. The most dominant of the goats is called the Top Buck. Similarly, the most dominant doe is known as Flock queen. This buck takes the responsibility of protecting the whole herd and generally guards the flock of goats from the rear direction when the goats are on the move. He takes the responsibility of choosing the doe which acts as second in command.

The doe that dominates the group is called the "Flock Queen." She is committed to guide and lead the herd especially for selecting suitable areas for grazing purpose. It is the doe that determines a suitable spot and other goats follow suit and start grazing in the spot that was found by the doe. If the Flock Queen moves away from the herd, it results in chaos and confusion among the goats. Even if the queen comes across a plant that may be poisonous or dangerous the it sniffs the plant and the snorts which means that there is an imminent danger from the plant. Other goats also sniff and identify the plant and then the Queen squash the plant.

This behaviour of goats is the motivating factor for the proposed clustering technique where it is presumed that 100 nodes are scattered in a fixed uniform region and energies of the nodes vary randomly. About 10 groups are formed with each group comprising of about 8 to 12 nodes in each group. In each group two nodes are selected which will, act as Cluster heads akin to Top buck and Flock Queen. The nodes accumulate the data and

shiftit to the sink. Normally the data is transferred or relayed to the sink directly but if the distance of sink is above the threshold, then there is a necessity to use an intermediate node for transmission of data. After sometime as data communication continues,the energy of cluster head is exhausted and reaches a threshold the next cluster head takes over and communication continues This process continues till the energy of second cluster head is also exhausted. On comparison of this technique with the existing techniques, this method shows an improvement in lifetime and energy consumption

On the basis of the above behavior of goats, a technique is proposed. It is presumed that there are 100 goats which form 10 groups and every group may consist of 8 to 12 goats. Similarly, we presume that 100 nodes scattered in an area of 300m×300m,.These clusters are formed by drawing 10 squares and node falling in that particular square 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 two nodes are reserved to act as cluster heads though they may also participate in data collection except the node that acts as Cluster head. Each of these two nodes will act as Cluster heads one after the other after exhaustion of their energies. After cluster aggregation, next follows the selection of Cluster head which is obviously the node that has the highest energy among all nodes. The remaining nodes gather data and forward it to the head in each cluster. The CH uses up all of its energy and after a few communication rounds are over and are unable to continue the conversation. This is the time when the node with second highest energy nodes takes over as CH and communication continues without hindrance.

The cluster will eventually be reduced to small sizes after the second cluster head also exhausts its energy. A modification is now suggested that after many nodes have exhausted their energies and no. of nodes that are in working mode are reduced to half, two clusters are joined to create a new group or cluster, a new head is chosen, so that communication continues for a longer period of time. Consequently, this process of re-clustering occurs, extending the sensor network's lifespan. A predetermined fitness function is used to choose these nodes, also called Relay nodes.

The method that has been discussed consists of the following steps.

a) An area that is square in nature with dimensions 300m×300m is presumed and about 100 nodes are dispensed randomly.
b) These nodes are allotted random energies.
c) It is assumed that the the sink shall be located at a distance from the square area.
d) Next 10 clusters are formed with every cluster.
e) These clusters are created by dividing square area into 10 small squares.
f) These clusters are marked sequentially with initial cluster as 1 till 10.
g) Energies of every node are measured.
h) In each cluster, the node that has the optimum energy shall be designated as Head.
i) Data forwarding to the Cluster heads is the responsibility of the remaining nodes after that.
j) The statistics that are aggregated data is then sent to the sink by the cluster heads.
k) In order to send data, an intermediary node must be used in case the sink is at a greater distance ie. above a predefined threshold distance.
l) After the first round of communication is concluded it is possible that energies of the cluster heads have exhausted or decreased to an extent that their energies are lesser than other nodes.
m) Then the node with the largest energy acts substitutes as cluster head in every cluster.
n) Again, communications take place for few many rounds. Energies of nodes after every round are computed.
o) After energy of the present cluster head reaches its threshold, and energy of some nodes is exhausted then these nodes stop participating in the communication process.

p) Then two clusters nearer to each other combine together into a new cluster. Now, the number of clusters lessen from 10 to 5 and communication continues.
q) This process continues till energy of remaining nodes and cluster heads reaches its threshold and communication stops.
r) Then routing process is envisaged wherein firstly the source node is determined. Base station is considered as the destination node.
s) Now the span across source and sink is computed.
t) If the span is greater than the predefined limit, necessity of intermediate node is envisaged and selected.
u) All the remaining cluster heads between source and sink are selected.
v) The energy of cluster heads in this area is computed.
w) The cluster head that has the utmost energy is selected as intermediate node.
x) Data is transmitted through this cluster head.

Sr. No	Simulation Parameters	Values
1	Channel Type	Wireless
2	Network Size	300m × 300m
3	Number of Nodes	100
4	Transmitting power	2mw
5	Packet size	1000bits
6	Performance parameters	Number of Alive Nodes and lifetime and energy consumption.

IV. RESULTS

NS2 simulation has been used to test the method proposed in this paper.It is assumed that the traffic pattern is constantly active with a constant bit rate (CBR). For calculating purposes, a threshold of 0.2 mj is taken into account for every node. The characteristics that are computed and compared in this approach are the alive node count, energy consumed as well as network lifespan. Table 1 shows the values of various variables presumed.

Table 1

Suggested method is contrasted with other contemporary bioinspired methodologies, including Genetic (GO), Particle Swarm Optimization (PSO), Horse Optimization (HO), and Elephant Herd Optimization (EHO), as shown in Fig. 1. Compared to the various methods already in use, it has been shown that the suggested strategy, which consists of 838 rounds, operates for the longest duration.

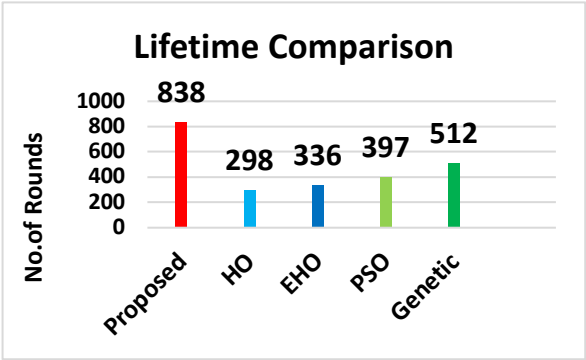

Fig.1.

Fig.1 shows the graph for number of rounds contrasted with other existing techniquesand on observation it can be concluded that the proposed technique runs for 838 rounds which is longer as compared to the existing techniques.

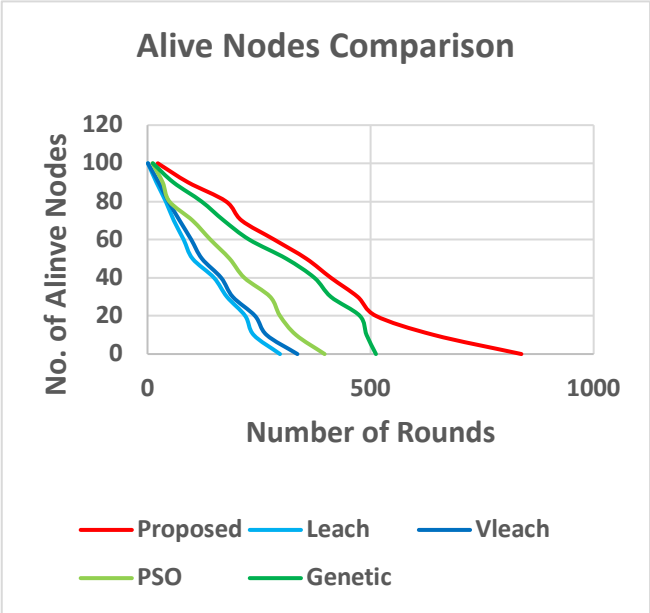

Fig.2

Fig.2 juxtaposes the proposed technique with other comparable techniques by considering the parameter of number of alive nodes. It can be observed that the nodes in case of all existing comparable techniques die earlier. So, it can be concluded that the proposed technique has a better efficiency and longer lifespan.

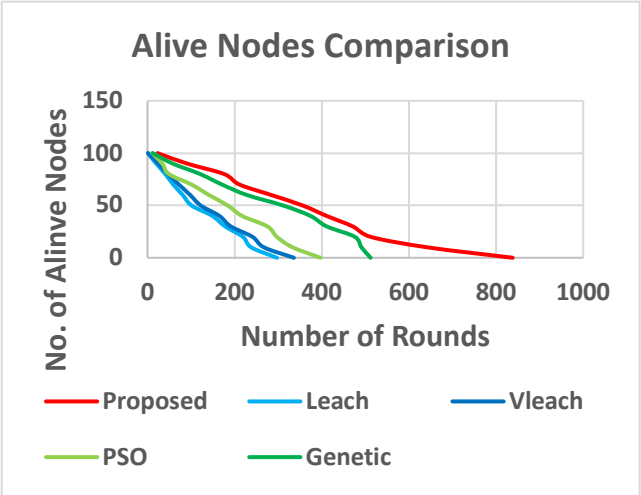

Fig.3.

Fig. 3 juxtaposes the suggested technique with the other comparable techniques considering the parameter of energy consumption. Energy consumed during the implementation of the proposed techniques with the other comparable technique shows this technique consumes lesser energy and hence gives a longer lifespan when contrasted with other comparable techniques.

V.CONCLUSION

A novel and distinctive clustering and routing method inspired by the goat behaviour is presented in the aforementioned research. By using uniform squares to divide the nodes into groups of about ten each, clustering is accomplished. A fitness function based on minimum distance and maximum energy is then used for routing, and if the distance exceeds a predetermined threshold, then an intermediate node is used for transmission of data. With this approach, it is shown that more nodes remain alive for longer periods of time. Additionally, this technique requires less energy than others. Consequently, it may be said that the approach used here yields better results than other comparable contemporary approaches. The proposed method is contrasted with the existent, predominant as well as old techniques such as the particle swarm optimization, Genetic based algorithm as well as the newly proposed Elephant herd optimization and horse optimization techniques. The unique features of the proposed techniques that use re-clustering technique, the longevity of clusters further increases. Also, the use of selection of intermediary node for routing helps in sustaining the information transfer extended duration and hence ensuring longevity of the sensor network.

REFERENCES

[1] Sandra Sendra, Lorena Parra, Jaime Lloret and Shafiullah Khan "Systems and Algorithms for Wireless Sensor Networks Based on Animal and Natural Behavior", Hindawi Publishing Corporation International Journal of Distributed Sensor Networks,1-19 Technology (TACT), 4(2),2015, pp. 587-594.

[2]Chun-Wei Tsai, Tzung Pei Hong, and Guo Neng Shiu, "Meta heuristics for the Lifetime of WSN: A Review", IEEE Sensors Journal, 16(9),2016, pp.2812-2831.

[3]Trupti Mayee Behera, Sushanta Kumar Mohapatra, Umesh Chandra Samal, Mohammad S. Khan "Residual Energy-Based Cluster-Head Selection in WSNs for IoT Application" IEEE Internet Of Things Journal, Vol. 6, No. 3, June 2019 pp.5132-5139

[4] Shaha Al-Otaibi, Amal Al-Rasheed, Romany F. Mansour, Eunmok Yang, Gyanendra Prasad Joshi, And Woong Cho "Hybridization of Metaheuristic Algorithm for Dynamic Cluster-Based Routing Protocol in Wireless Sensor Networks" IEEE ACESS, Volume 9, 2021 T, pp. 83751- 83761.

[5] Angeeta AH, Nitin NKJ, Ravi RS, New Hybrid Clustering and Routing Algorithm for Energy-Harvesting Wireless Sensor Network, Research Square, 21 Feb 2023,1-24.

[6] Juhi Agrawal 1, * and Muhammad Yeasir Arafat Bio-Inspired Algorithms for Efficient Clustering and Routing in Flying Ad Hoc Networks Sensors 2025, 25, 72,1-26

[7] Abhilash Singha, Sandeep Sharma, Jitendra Singh, "Nature-Inspired Algorithms for Wireless Sensor Networks: A Comprehensive Survey", arXiv: 2101.10453v1, 24 Dec 2020 pp.1-53.

[8]Yefei Zhang, Yichuan Wang, "A novel energy-aware bio-inspired clustering scheme for Io Communication", Journal of Ambient Intelligence and Humanized Computing,2020,11, pp.4239–4248.

[9] Rashmi Ranjan Sahoo, Abdur Rahaman Sardar, Moutushi Singh, Sadabindu, Subir Kumar Sarkar, "A bio inspired and trust-based approach for clustering in WSN", NatComput (2016) 15, pp.423–434.

[10] Dr. Sami Halawani, Abdul Waheed Khan, "Sensors Lifetime Enhancement Techniques in Wireless Sensor Networks - A Survey", Journal of Computing, Volume 2, Issue 5, May 2010, pp.34-47

[11] Devika Ramesh D, Asha Gowda Karegowda, "An Energy Efficient Routing and Compression Based Data Collection Applying Bio-Inspired Ant-Cuckoo Technique for Wireless Sensor Network",978-1-7281-2619-7/19/$31.00 ©2019 IEEE.

[12] Amreen. S. I, Mohaideen Abdul Kadhar, Sathiya Girija, "Particle Swarm Optimization based Load Balancing Clustering Technique for Wireless Sensor Networks", 6th International Conference on Advanced Computing & Communication Systems (ICACCS),2020. pp.1228-1233.

[13] Yuan Zhou, Ning Wang, and Wei Xiang, "Clustering Hierarchy Protocol in Wireless Sensor Networks Using an Improved PSO Algorithm", DOI.

[14] R. K. Krishna and B. SeethaRamanjaneyulu, "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.

[15] R. K. Krishna and B. SeethaRamanjaneyulu, "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.

[16] R.K. Krishna, B. SeethaRamanjaneyulu "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.

[17] 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.

[18] QiangTu, Yitong Liu, Yi Xie, Xincheng Liu, "Energy Efficient Clustering Protocol Based on Binary Salp Swarm Algorithm for Heterogeneous Wireless Sensor Networks", 2020 IEEE 6th International Conference on Computer and Communications (ICCC) pp.863-868

[19] Mandeep Kaur and Balwinder Singh Soh, "Comparative Analysis of Bio Inspired Optimization Techniques in Wireless Sensor Networks with GAPS Approach", Indian Journal of Science and Technology, Vol 11(4), January 2018pp.1-10.

[20] 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, December 2015, Volume: 06, Issue: 04, pp 1173-1181.

[21] K Basil Baby and M Lingaraj "Bio-Inspired Routing Protocol to Enhance Performance of Wireless Sensor Network "Journal of Physics: Conference Series ICASSCT 20211921 (2021) 012078 pp1-7.

[22] P. Visu, T. Suriya Praba, N. Sivakumar, R. Srinivasan, T. Sethukarasi, "Bio-inspired dual cluster heads optimized routing algorithm for wireless sensor networks", Journal of Ambient Intelligence and Humanized Computing,2021, pp. 3753–3761.

[23] SM. Mahdi H. Daneshvar, Pardis Alikhan Ahari Mohajer, And Sayyed Majid Mazinani, "Energy-Efficient Routing in WSN: A centralized Cluster-Based Approach via Grey Wolf Optimizer", IEEE ACESS, VOLUME 7, 2019, pp. 170019 -170031.

[24] Doaa Mohsin Majeed, Hasan WahhabRabee, "Improving Energy Consumption Using Fuzzy-GA Clustering and ACO Routing in WSN", 2020 3rd International Conference on Artificial Intelligence and Big Data pp.293-298.

[25] Yefei Zhang, Yichuan Wang, "A novel energy-aware bio-inspired clustering scheme for IoT Communication", Journal of Ambient Intelligence and Humanized Computing, 2020, pp.4239-4248.

[26] Tanima Bhowmik, Indrajit Banerjee, "An Improved PSOGSA for Clustering and Routing in WSNs" Wireless Personal Communications November, 2021, pp.431–459.

[27] 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), 2020, pp.106-113.

[28] Aliaa M. Abdali, Nia Yesh Gharaei, and Arwa A. Mashat (2021). A Framework for Energy-Efficient Clustering with Utilizing Wireless Energy, IEEE ACCESS Volume 9, 2021 pp.117823 - 117831.

[29] Botao Zhu, Ebrahim Bedeer, Ha H. Nguyen, Robert Barton, and Jerome Henry (2021). Improved Soft-k-Means Clustering Algorithm for Balancing Energy Consumption in Wireless Sensor Networks IEEE INTERNET OF THINGS JOURNAL, VOL. 8, NO.6, MARCH 15, 2021 pp.4868-4881.

[30] Ramamurthy Garimella, Padmalaya Nayak, Mohammed Nazeer, K. Ramesh (2020) Constrained Clustering Approach in Wireless Sensor Networks to Minimize the Energy Consumption,2020 IEEE International Symposium on Sustainable Energy, Signal Processing and Cyber Security (ISSSC) .

[31] Dr. Sunayana Jadhav (2021). Hierarchical VSCH and Cluster-Tree Routing Algorithms for Energy Efficient WSNs 2021 International Conference on Intelligent Technologies (CONIT)Karnataka, India. June 25-27, 2021 pp. 1-4

[32] Hajer Faris Fadhel, Musaria Karim Mahmood, Osama Al-Omari (2021) A Comprehensive Analysis of Energy Dissipation in LEACH Protocol for Wireless Sensor Networks, 2021 18th International Multi-Conference on Systems, Signals & Devices (SSD'21), pp 53-57.

[33] Arun Avinash Chauhan, Siba Kumar Udgata (2020). Load Balancing in Wireless Sensor Networks using Multiple Cluster Heads, 2020 IEEE-HYDCON.

[34] Ankit Kumar, Dr. Pankaj Dadheech, Utpal Aditya Chaudhary (2020). Energy Conservation in WSN: A Review of Current Techniques, 3rd International Conference on Emerging Technologies in Computer Engineering: Machine Learning and Internet of Things (ICETCE-2020), 07-08 February 2020, pp.256-263.

[35] Doaa Mohsin Majeed, Hasan Wahhab Rabee, Zhenjie Ma (2020). 3rd International Conference on Artificial Intelligence and Big Data, pp.293-298.

[36] Amrieen. S. I, Mohaideen Abdul Kadhar. K, Sathiya Girija. H (2020). Particle Swarm Optimization based Load Balancing Clustering Technique for Wireless Sensor Networks.20206th International Conference on