Improved Network Stability in Wireless Sensor Network By Hybrid Evolutionary Approach Using Water Cycle Optimization

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Abstract-Wireless sensor network is a group of nodes that are connected to each other by wireless connection. These type of network work on the dynamic topology of the network because positions of nodes in the wireless network are changing continuously. The nodes in WSN are basically made up of small electronics device which are used for sensing, computing and transmitting the data. The nodes are run on the battery power during communication process. The battery consumption in WSN is very high due to high computation operations on it. In the recent years WSN grows at very high at the research area is also increased in this field to provide effective computation. By considering the network structure routing is categorized into two parts that are flat and hierarchical routing. In this proposed work cluster are made by WCA-GA (Grey Wolf optimization) on the basis of distance and energy parameters. The cluster head is also selected on the basis of WCA-GA and GSA in three different metrics. At the end the performance evaluation of the proposed work is compared with the existing approach Leach on the parameters of Throughput, alive nodes, and Average residual energy.

Keywords- Wireless Sensor Networks, Grey Wolf optimization, Artificial Neural Network, Clustering Algorithm.

I. INTRODUCTION

WSN are thick wireless networks of little, cheap, low-control, disseminated self-ruling sensors which a mass and prolife rate natural information to encourage checking and controlling of physical conditions from remote areas with better exactness. For the most part, it is accepted that every sensor in a system has certain limitations as for its vitality source, power, and memory and figuring capacities. It contains a door that gives wireless network back to the wired world and dispersed nodes. It can likewise be characterized as a system of gadgets that can impart the data accumulated from an observed field through wireless connections. The information is sent through different nodes with an entryway and the information is conveyed to different networks like wireless Ethernet. These networks are utilized to control physical or ecological conditions like sound, weight, temperature and so forth. WSN nodes have constrained battery limit. As the use of WSN is increasing rapidly and simultaneously this technology is facing various major challenges of energy constraints depending upon the limited lifetime of batteries as each of its node relies on energy demand for performing the basic operational activities which has become the major reason behind the failure in wireless sensor networks [2,3][4].

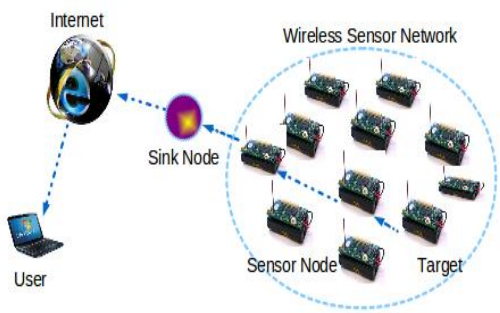

Figure 1: Wireless Sensor Network

One node interruption may result in shutting down the overall operation of the system. The nodal operation relies on active mode, idle, and sleeping modes. In case of active modes, energy is consumed while transmitting or receiving the data. In case of idle mode, the node consumes the energy same as consumed in active type node whereas in case of sleeping mode, the node gets shut down in order to save the energy [5-7][8-10].

1.1 Characteristics of WSN

The characteristics of WSN include the following:

- The consumption of power limits for nodes with batteries.
- Capacity to handle node failures.
- Heterogeneity of nodes and some mobility of nodes.
- Large scale distribution scalability.
- Ensure and maintaining strict environmental conditions.
- Cross-layer design.
- Simple/ Easy to use.

1.2 WSN: Types

The WSN technology is based on different types of sensors discussed below:

(a) Terrestrial WSNs: These types of nodes can be located in a structured or unstructured manner. In case of unstructured mode, each of the sensor node gets distributed on random basis but kept within the specified or targeted area.

(b) Underground WSNs: The underground sensors are costlier than the terrestrial WSNs technology. But these systems are used effectively in monitoring the underground operational activities. The whole activity occurs underground but the information is passed to the

station with the help of sink nodes that are present above the ground.

(c) Underwater WSNs: It is compose of a vehicle and a sensor node placed under water. The vehicles are used to get the data from the sensor nodes. The big major challenges of this process are sensor failures and the long propagation delay processes. The battery life of such WSNs is also limited and is not rechargeable. Therefore, distinct techniques have been used for the solving the issues related to this type of WSN.

(d) Multimedia WSNs: These type of sensors collects the data in the form of video, audio and imaging. Here, the sensor nodes are linked to microphones and cameras which would monitor and track the different events connected and keep an eye over all the events.

(e) Mobile WSNs: This process relies on using the sensor nodes moving from one place to another. They are interfaced very easily within the adopted environment.

1.3 WSN Attacks

The following section describes some basic forms of attacks launched in WSNs [14].

(a) Outsider vs. Insider attack: In case of outsider attacks, the malevolent nodes harms the WSN technology without any kind of involvement in the process whereas in case ofan insider attack, the nodes that are malevolent or malicious harms the WSN process as an authorized part of it

*(***b) Active vs. Passive attack:** In case of an active attack, the communication in the WSN is directly influenced by the adversary with the data-packets modification, suppression, and the fabrication methodology whereas in case of passive attack, an adversary only monitors or eavesdrops the WSN communication process.

(c) Remote vs. Physical attack*:* A remote attack gets implemented from a greater or large distance for example, the high energy signal emission for interrupting the WSN communication. On the other hand, the physical form of attack, the main role of adversary is to physically access the node sensor that gets harmed by destroying or tampering the hardware of the sensor.

(d) HELLO flood attack: Injects (intentionally) the bogus HELLO messages to the nodes placed remotely in order to confuse the protocol of routing.

(e) Black hole/ Sinkhole attack: The attacked form tries to gain all the packets in the network in a specified area by an attractive looks to the surrounding neighbouring nodes.

(f) Sybil attack: It creates a pseudonymous entities in large to have a greater impact on the network.

(g) Wormhole attack: Here, the two nodes believe that they are neighbours of each other with the help of tunnelling packets using a low link latency, as in real they are far from each other.

1.4 WSN: Routing Protocols

The routing approaches adapted by different mobile network are shown and discussed [11-13, 15]. These protocols are given below in figure 2.

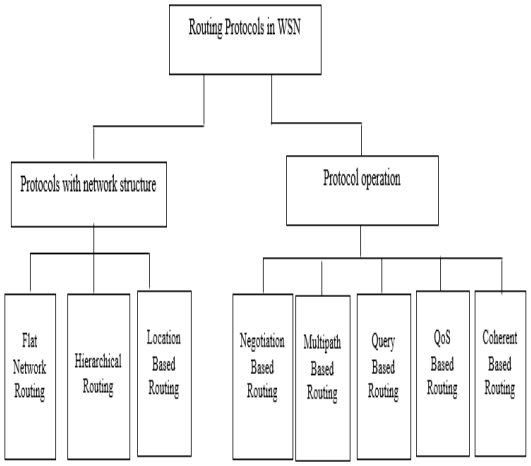

Figure 2: Routing Approaches/Protocols

1.4.1 The Network Structure Protocol

It basically consists of the following routing protocols:

1. Flat Based Routing: Such kind of routing technique is used in identical network with randomized parameters guidance. All the network nodes are of same type and the multi hop route is used to optimize the network route. In most of the intra-cluster mobile network, these kind of routing approach is been used to carry out the network communication. This routing approach works on the destination adaptive and data adaptive communication carried out over the network. The first data-centric protocol used is named as SPIN.

(a) SPIN (Sensor Protocols for Information via Negotiation): The planning done behind the SPIN methodology was to perform data naming using descriptors or meta-data of very high level. Swapping of meta-data is done among the sensing nodes before the process of transmission via data-advertising strategy that forms the basic key feature of the SPIN protocols. In this SPIN protocol, the topological transformations are usually of localized form as each and every node needs to have or to know its single-hop type neighbours.

(b) Directed Diffusion (DD): The main objective of Directed Diffusion to diffuse the data through the sensing nodes with the help of utilization of data naming scheme. It requires the utilization of pairs of attributes based values for the data and queries the sensors on urgent demand basis with the use of the pairs discussed The DDs are highly energy efficient as they occur on demand basis and there is no such need for keeping the network topology (globally).

(c) Rumor Routing (RR): It represents a compromising condition between the notifications of flooding events and the queries of flooding. It easily routes to the event directly and if in case the path is not discovered, the re-submission of query is tried. So, RR represents a very good class of query based delivery to the events within large networks.

2. Hierarchical Routing: In this routing technique, the inter cluster communication is carried out. The nodes can identical or different but the nodes in a same network are considered as identical. This protocol is based on two of its hierarchical types explained as follows:

(a) Low-energy adaptive clustering hierarchy (LEACH): It was basically proposed for lowering the power consumption process. It relies on the process of data-aggregation which combines the data original form into small pieces of data carrying only requires meaningful

data form to each and every sensor. LEACH is not applicable to large network based applications. The CHs used in LEACH consumes greater energy when the nodes gets located far away from the sinks.

(b) Power efficient gathering in sensor information systems (PEGASIS): It forms an extension of LEACH protocol forming sensor nodes chain such that each of the sensor node receives and transmits from its neighbors. PEGASIS helps in avoiding the formation of clusters and that's why uses only node for the transmitting purpose instead of using nodes in a multiple form

(c) Hybrid, Energy-Efficient Distributed Clustering (HEED): It works on the four types of major goals such as (i) Prolonging lifetime of the network by distributed consumption of energy (ii) clustering process termination within iterations of constant number (iii) reducing the control overhead, and (iv) fabricating CHs in a very well distributed way and compact form of clusters.

(d) Threshold sensitive energy-efficient sensor network (TEEN) Protocol: It represents a hierarchical clustering protocol and basically uses the method data-centric approach along with hierarchical approach.

3. Location Based Routing: The routing technique explained here for the guidance of network node and tracking of node under the location guidance and creation. The classification of location-based routing is described as follows based on figure.3.

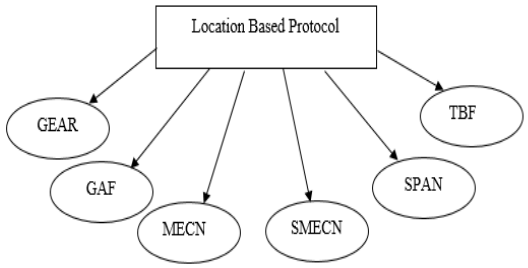

Figure 3: Location Based Protocol

(a) GEAR: It mainly used to reduce consumption of energy for the network routing setup, but and it also provides better delivery of the data packet.

(b) GAF: Geographic Adaptive Fidelity basically favors the WSN energy consumption. It works on three of its important stages: discovery, active and sleeping.

(c) MECN: Minimum energy communication network (MECN) maintains and establishes WSNs minimum network of energy utilizing low power consuming GPS. This type of protocol has two of its phases:

- I t usually takes 2d plane position and models a graph (thin).
- I t searches the best link possible on the enclosure graph and utilizes the shortest distributed path algorithm with consumption of energy as a cost metric.

(d) SMECN: It is a modified version of MECN. It consumes less energy as compared to MECN and the cost of its maintenance is also low but the major drawback is that it introduces more overheads as searching the sub-networks with small number of edges is a very complex process.

1.4.2 Operational part of protocol

It includes various types of protocols [1][15] as illustrated in figure.2

1. Multi path-based: This method provides an efficient methodology that handles multiple paths. This pathway provides an additional/alternative path when the primary method fails. The system's fault tolerance level and the reliability increases due to alternative path provided.

2. Query-based: This type of routing uses the queries that are usually issued by the base station. Here, the base station send certain queries and requests for collecting the information in the network with the help of sensor nodes.

3. Negotiation-based: The negotiation based protocols uses a highly coded descriptors in order to eliminate the data redundancy.

4. Quality of Service (QoS)-based: This type of protocol requires to maintain both the energy and the quality within the network. When the sink requests or queries the data from the sensor nodes, this process of transmission must satisfy few parameters of quality-of-service (QoS) like the latency i.e. bounded where the data is sent surpassing the delayed operation quickly and the second parameter is the bandwidth consumed.

5. Coherent-based: Within the network, the process basically relies on two types of data processing techniques. One is the coherent type and the other is the non-coherent type technique. In case of non-coherent technique all types of nodes collect the data and processes it before sending it to its nearest neighbour for further processing and the sensor nodes performing such processing are named as aggregators whereas in case of coherent routing, just after the minimized processing operation, the data or the information is sent to the aggregators.

II. RELATED WORK

Aggarwal, D. et. al. [1] Fuzzy based unequal clustering algorithm is proposed by the author in this article to enhance the lifetime of the wireless sensor network. It balanced the energy consumption by making the unequal clusters. Cluster heads are selected by using the fuzzy logic. Density, energy and base station distance are the input variables of the network. Rank and competition radius are the outputs of the fuzzy system. The performance of the proposed algorithm is compared with existing protocols and found that the proposed algorithm performs better. **Tan, C. et. al. [2]** introduced FAEM data collection protocol which is used for energy efficient multicast multichannel routing in wireless sensor networks. It works on the basketball net topology in which it establishes a table for each node and also pre-assigns the channel which is different from the neighbour nodes. Time is divided into duty cycle and each cycle consists of two phases. The first phase called iterative scheduling phase and second phase called as slot-based packet forwarding phase. In this network tree upload nodes are called parent node and download nodes are called child node. Results of the proposed method give low energy consumption, low latency, and high data reliability. **Bahbahani, et. al. [3]** proposed cooperative clustering protocol to enhance the longevity of energy harvesting based WSN. It maintains the energy consumption between the cluster heads and nodes according to the duty cycle. In this TDMA approach is used with the cross-layer approach. Performance of the proposed system is analyzed by using parameters bandwidth utilization, latency, and energy consumption. **Saleh Ahmed, I. et. al. [4]** Multi-aware Query Driven routing protocol is proposed for wireless

sensor network which is based on the neuro-fuzzy system. This protocol focused on the life of the sensor, delay transmission of data and total cost of network and path on the network. Fuzzy rules are used to select the proper path. The performance evaluation is done by comparing the proposed protocol with the existing and it provides best data delivery with minimum routing overhead. In Sen, **GB Zionna et al. [5]** Rumor Routing is proposed with fuzzy logic to reduce the energy consumption. It works on the three factors centrality, energy, and distance. Network efficiency is enhanced by using this approach. **Kulshrestha et al. [6]** introduced an adaptive energy balanced and energy efficient approach for data gathering in wireless sensor networks. This method considers the neighbor nodes and link reliability to determine the energy consumption on nodes. This mechanism reduced the end-to-end delay and energy consumption in the wireless networks. In this work, the author uses Forwarding approach to reduce the excessive overhead in the multi-hop network. The result of the paper shows that it reduced the message overhead, energy consumption, and end-to-end delay. **Zhang, X. et. al. [7]** Energy efficient MAC protocol is proposed for wireless sensor networks. It works on the basis of best partnership selection algorithm which considers the energy consumption during the data transmission. It checks the total power allocated to the senders to transmit data packets. This protocol gives congestion free network and nodes consuming low energy. **Bouachir, O. et. al. [8]** introduced EAMP-AIDC energy-aware protocol which works on the basis of duty cycle optimization. Duty cycle considers the active and sleep periods of the nodes which are used for balancing of the nodes. This experiment is performed on OMNET++ and gives better energy consumption and enhanced the energy savings over the network. **Hong, C. et. al. [9]** proposed hybrid beaconless geographic routing. In this approach data packets are divided into two type of packet that are normal packets and delay sensitive packets. It uses two kind of handshake mechanism for delay sensitive packets that are request to send and clear to send. Priority method is used for the channel assignment. The analysis of the proposed approach shows that delay sensitive packets have lower latency and higher packet delivery ratio and low energy consumption. **Doudou, M. et. al. [10]** Cascading wake-up MAC protocol is proposed low power wireless sensor network. This work mainly focused on energy/delay, optimization and switches between two modes on the basis of traffic type and delay. First mode is high duty cycle and second mode is low duty cycle these modes are used to adjust the wake-up nodes according to load. The proposed MAC protocol is compared with existing protocol and it performs better in energy saving and data delay reduction. **Zhuo, S. et. al. [11]** introduced i-Queue MAC a hybrid protocol which supports the CSMA and TDMA in variable traffic. When the load is light on the WSN then it uses contention based CSMA and transfer data with low delay and scattered transmission. When the traffic is high on WSN then it uses contention free TDMA mechanism and allocates the transmission slots. The proposed method reduced the packet buffering and packet delay by combining TDMA and CSMA. This method works effectively on single and multichannel modes. **Jacob et. al. [12]** to reduce the energy consumption on the wireless sensor network PHY-MAC cross layer design is proposed by the author in this article. Sleep time vary according to the information comes from the physical layer. To solve this issue Sensor-MAC protocol is used which uses sleep-wake up cycles and enhance the performance of the system. This protocol reduced the network failure and enhances the lifetime of the network.

III. THE PROPOSED METHOD

3.1 Proposed Methodology

Step 1: Deploy the wireless sensor network.
Step 2: Make the cluster of nodes in WSN
Step 3: Use the distance and energy of the nodes.
Step 4: Check the distance from the sink node.
Step 5: Initialize the WCA_GA and input the population as nodes.
Step 6: Set (NewCH/OldCH)= - ∞
Step 7: After this compute the fitness functionand objective function.
Step 8: Update the value of cluster head θ^*
Step 9: Analyze the value of dead node, live node, throughput and energy of nodes.

3.2 Proposed methodology: Flowchart

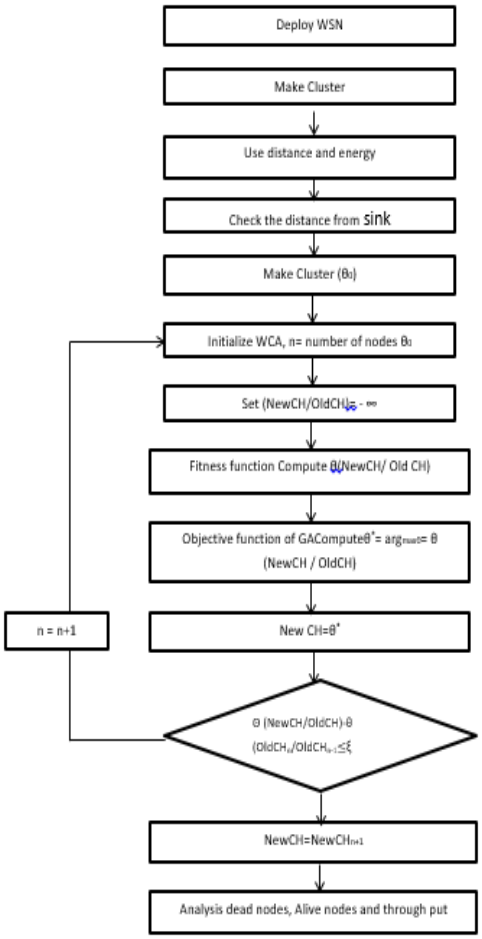

Figure 4: Proposed Flowchart

3.3 Algorithm Used

1. Water Cycle Algorithm (WCA): The latest bio-inspired algorithm is the water cycle optimization algorithm. This algorithm's main concept is simulating the behaviour of grey wolf living in a pack. They have a serious hierarchy of social dominance. Alpha is known as the level leaders and is responsible for decision making in the pack. The wolf pack persistence is based on the decision of alpha. Beta is known as the second level

subordinate wolves. The beta operation is for help in making the decision for alpha or other activities.
Proposed steps:

Step1 : Deploy the wireless Sensor network.
Step2 : Apply the leach routing process.
Step3 : Simulate the black hole attack on the wireless Sensor network and parallel optimize by WCA algorithm.
Step4 : {
Initialize the water cycle optimization

- Update the fitness function.
- Check the objective function
- Check it optimize or not it optimized then analysis the time and dead node otherwise check the counter is greater than 0 or not. If the counter value is less than not converge and ignore the node during routing. Else again initialize the value at WCA

}

2. Gravitational Search Algorithm: The current trend encourages connecting the WSN to outside networks in order to allow remote data collection and control, which involves the use of the GSA protocol. From the viewpoint of mobility, there are also two types of mobility, micro and macro mobility (Figure.5): (i) the micro-mobility is when nodes move within the same field (e.g. nodes move within the same network or to another network that uses the same GSA prefix). Within this area, a Mobile Node (MN) can change its access point without changing the GSA prefix. (ii) In contrast, the Macro-mobility is when nodes move between different areas.

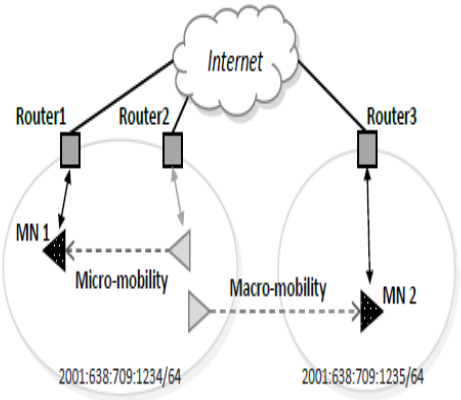

Figure 5: GSA Based Wireless sensors Network

IV. RESULT ANALYSIS

4.1 Introduction

The performance evaluation of the proposed WCA_GA Leach is compared with GSA Leach and with Leach also. The comparison based on the number of rounds and the nodes in the cloud. The comparison is based on the following parameters:-

- Live Nodes
- Throughput
- Average residual Energy

4.2 Result Analysis

Table 1: Number of Live Nodes

Number of Rounds	Number of Live Nodes (WCA_GA)	Number of Live Nodes (GSA)
500	290	150
1000	275	145
1500	225	125
2000	160	100
2500	145	90
3000	105	65
3500	75	55
4000	58	52
4500	55	50
5000	51	48

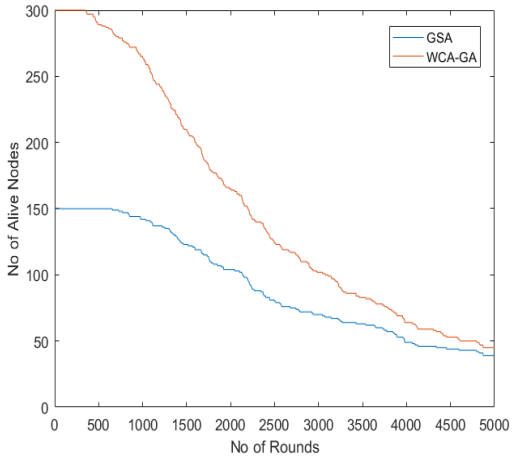

Figure 6: Number of live nodes in WCA_GA Leach and GSA Leach

The above given Figure 6 represents the live nodes in the number of rounds on the two algorithms WCA_GA Leach and GSA Leach. The Blue line on the graph represents the WCA_GA Leach and red line represents the GSA leach nodes. The round starts from the 0 to 1000 and the maximum number of live node is present in round 200 and changes according to the number of nodes changes.

Table 2: Throughput on WCA_GA Leach and GSA Leach

Number of Rounds	Throughput (WCA_GA)	Throughput (GSA)
500	1	0.5
1000	2.3	1.5
1500	4	2
2000	4.9	2.5
2500	5.8	3
3000	6.2	3.3
3500	6.8	3.7
4000	7	4
4500	7.3	4.2
5000	7.5	4.5

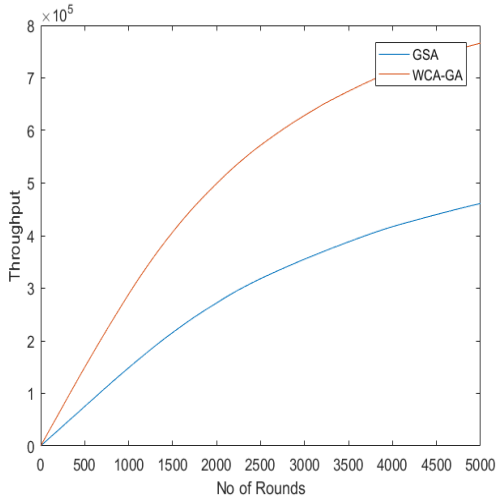

Figure 7: Throughput on WCA_GA Leach and GSA Leach

The above given Figure 7 represents the throughput in the number of rounds on the two algorithms WCA_GA Leach and GSA Leach. The Blue line on the graph represents the WCA_GA Leach and red line represents the GSA leach nodes. The throughput of the grey wolf optimization algorithm with Leach is better than the existing GSA.

Table 3: Average Residual Energy WCA_GA Leach and GSA Leach

Number of Rounds	Number of Live Nodes (WCA_GA)	Number of Live Nodes (GSA)
500	140	85
1000	100	60
1500	62	48
2000	52	35
2500	38	28
3000	25	22
3500	24	21
4000	23	19
4500	21	18
5000	19	15

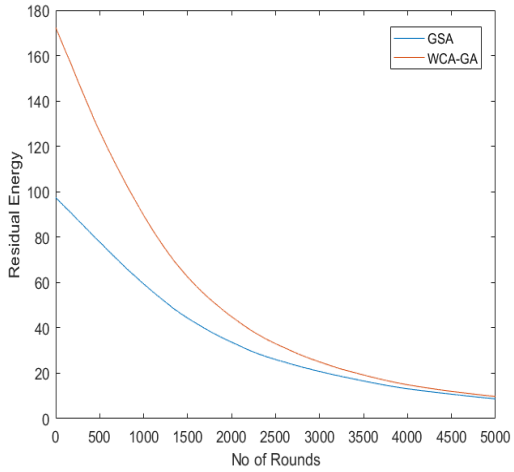

Figure 8: Average Residual Energy WCA_GA Leach and GSA Leach

The above given Figure 8 represents the average residual energy in the number of rounds on the two algorithms WCA_GA Leach and GSA Leach. The Blue line on the graph represents the WCA_GA Leach and red line represents the GSA leach nodes. The average residual energy of the grey wolf optimization algorithm with Leach is better than the existing GSA.

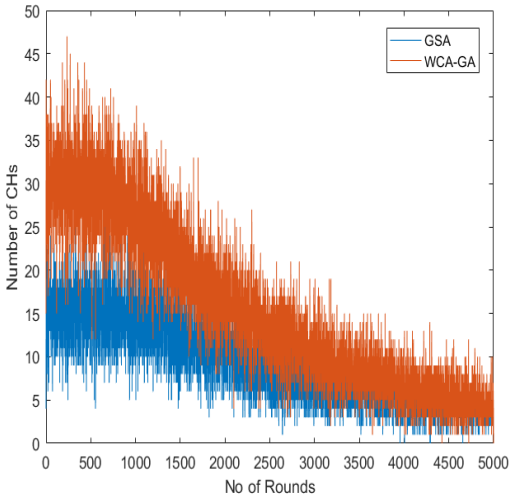

Figure 9: Cluster Heads according to rounds

The above given Figure 9 represents the cluster head in the number of rounds on the two algorithms WCA_GA Leach and GSA Leach. The Blue line on the graph represents the WCA_GA Leach and red line represents the GSA leach nodes. The spikes in the graph represent the changes in the algorithms according to the round

IV. CONCLUSION

Wireless sensor networks have gained a lot of attention is the last few years and used by the peoples in various applications and also in the military services. In WSN it is very challenging process to design a robust and scalable routing protocol which performs well at the time of data congestion on network. In the proposed work particle swarm optimization algorithm is used to provide the optimal result in the nodes of WSN. WCA_GA work on the biological behaviour of the swarms provides effective solution. In this work WCA_GA is used for selection of cluster heads according to their size. It works on the alive nodes, dead nodes and the energy consumption by the nodes. The results depict the WCA_GA performs better than the existing approach GSA LEACH and Leach in every scenario.

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