Novel Approach of Routing in wireless sensor network using grid topology with swarm intelligence

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Abstract-
Wireless Sensor network (WSN) is the important field of wireless communication. In wireless sensor network the basic challenge is battery power consumption. The Consumption of battery in data sending and data aggregation. So the important challenge is reduction of energy consumption. In grid clustering the entire area has been divided into small squares of cluster areas and in each round a separate cluster head has been assigned for each cluster. In this paper for cluster selection use optimization base method see its effect on cluster head and alive nodes stability. In experiments in different approaches of grid wireless sensor cluster selection by bacterial foraging optimization, particle swarm optimization and prediction based selection. Analysis is done on base simulation environment with 3000 rounds, 200 nodes and 300* 300 simulation areas. Graph represent Prediction base method cluster head dead within 500 rounds, BFO base method 1800 rounds and PSO base method not dead up to 3000 rounds. In this thesis, analysis of cluster head generates during packet sending process in grid based clustering. Above given graph clearly show the effective results by particle swarm optimization in cluster head numbers and alive nodes. In this work PSO is used because it performs local and global optimization. BFO supports only local optimization and it does not stabilize cluster heads and not effectively reduce thee alive nodes.

I. INTRODUCTION

In research world Wireless Sensor Network (WSN) is rapidly growing and now days for research scholar this is an emerging area. In environmental applications like earthquake information, animal tracking, weather information etc. WSNs are used. WSN are also used in business applications, hospitality, Military applications, security, and Military application. With limited storage space, data gathering, integrated sensing and processing ability the WSN is the collection of the tiny sensor nodes equipped. From sensing areas every tiny node has limited battery power which is used to sense the data. For the wireless sensor network the basic requirement is reduce the total energy consumption of the sensor nodes, while sensor nodes have limited battery power with limited lifetime then ultimately increase the survival time of network. During data sensing the battery of sensor nodes cannot be change in the sensor network areas [1, 6]. In various fields from commercial and industrial to military areas WSNs are used. Economically these have ability to communicate, energy, viable, constrained memory and computing power. For computations by energy consumption the lifetime of node and network are directly influenced. With the nodes using hop-distance connectivity comprising of wireless communication links the data is transmitted towards the base station, in an insecure communication medium they communicate and they often operate unattended, where in a secure manner the data need to be sent. In wireless sensor networks basic security services are provided by the pairwise keying process. A low-power domain is typical public-key cryptography, using key encryption algorithm uses cryptanalysis to extract information for the secure transmission. As symmetric or asymmetric the cryptographic algorithms can be classified. In the network the nodes are deterministic; for key distribution and secure communication the network uses clustering technique. Different keys maintain by the all nodes in a cluster, but with the base station every node uses same key for different communications [2, 8]. A wireless sensor network (WSN) has the ability of communicating, sensing and computing and is a group of spatially scattered hundreds or thousands sensor nodes. In physical spaces it embedded; from the environment continuously gather a big amount of data. Thereafter in many domains such as monitoring, scientific investigations, tracking and more WSN is beneficial technology. With a certain topology in an area any WSN incorporate several sinks or single, several or single sources and many sensor nodes are organized. Such as humidity sensor, pressure sensor, sound sensor, temperature sensor, et cetera the sensor nodes can contain different. From the environment that it embedded in When this sensor nodes sense elements, data by using the processing units inside the sensor nodes through the analogue to digital converter module the analogue signal is converted in to digital, after that for processing the data is send to the base station. To the base station Wireless sensor node can communicate directly and also it can communicate with each other. The following components are contained by the sensor network:

- Collecting Data: during transducers that has the ability of acquisition and sensing.
- Transport Data: during the adhoc/wireless channels.
- Processing: to analyzing the data that has ability.

A. WSN Architecture

There are three main components in WSN: nodes, gateways and software. Spatially distributed measured node's interface with sensors to monitor assets. The collected data transmit to gateway wirelessly, and can operate independently. It is connected to a host system where we can collect data, process, analyze and present our measurement data by using a software. To extend WSN distance and reliability special type of measurement node is used such as router node. WSN is a widely used system because of its low costs and high efficiency [9,10]. In a typical wireless sensor network (WSN), sensor nodes consist of sensing, communicating, and data processing components. Sensor nodes can be used in numerous industrial, military, and agricultural applications, such as transportation traffic monitoring, environmental monitoring, smart offices, and battlefield surveillance. In these applications, sensors are deployed in an ad-hoc manner and operate autonomously. In these unattended environments, these sensors cannot be easily replaced or recharged, and energy consumption is the most critical problem that must be considered. The sensor is a small device which is used to detect the amount of physical parameters, event occurring, measures the presence of an object and then it converts the electrical signal value according to need it actuates a process using electrical actuators.

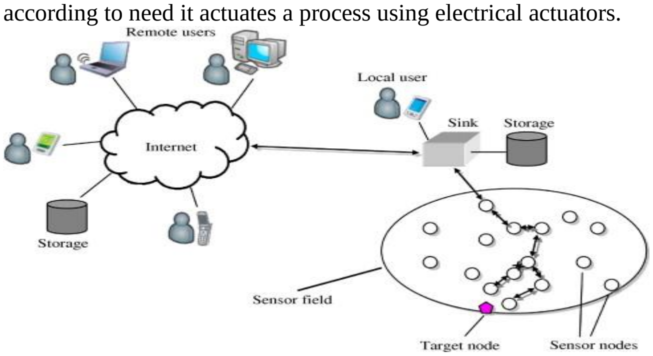

Fig.1 WSN Architecture

B. WSN TOPOLOGY

There are three type of WSN used for communication purpose which is termed as star topology, mesh topology, and tree topology [11]. When every single node is connected with gateway directly this network is termed as star topology and in tree topology every node is connected with a single node which is kept at the top of the tree and termed as tree topology and at last mesh topology, in this connection data transfer4 is done from one node to another node in a radio transmission range. In this this type of connection an intermediate node is required for transmission purpose. There are number of advantages and dis-advantages of these topologies:

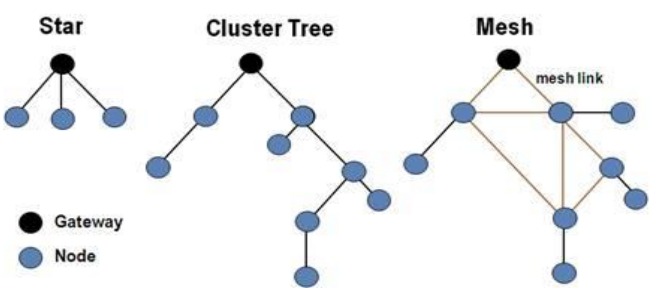

Fig.2 Topologies Networks

C.WSN: DESIGN ISSUES

Following are the main design issues in the WSAN which affects the performance of the system.

- **Network Dynamic**

Routing of the messages between the nodes in WSAN is more challenging task for the node stability and route stability. Stability factor is an important optimization factor with energy and bandwidth. The event can be static or dynamic it depends on the application.

- **Node Deployment**

Node deployment in the wireless sensor actor network is deterministic or self-organizing. The nodes and sensors are deployed manually in deterministic approach and predetrministic paths are used for data routing. In self organizing nodes are scattered randomly in ad-hoc manner.

- **Data Fusion**

The combination of data from different sources using a function such as min, max and average. These functions are done on sensor nodes for data reduction. Achieving the energy-efficient data fusion approach is a major problem for the heterogeneous network [1].

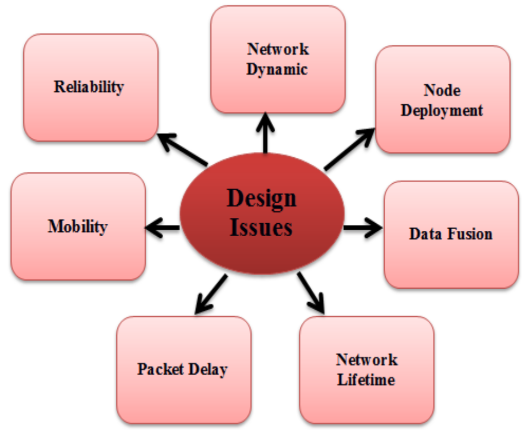

Fig.3 Design Issues of the WSAN

- **Network Lifetime**

The life time of the WSAN is limited due to the functioning of actor nodes from battery source. Basically the life time is defined as the percentage of dead nodes below thresholds.

- **Packet Delay**

The actor node's function in WSAN is to act on the sensed data quickly and perform the required operation. It is also a design issue to design the protocols which does not considers any delay in network and nodes gives best response.

- **Reliability**

The reliability of the nodes is giving the correct response by the actor nodes. Every actor nodes has a predefined time period in which it reconstructs the event, understand its intensity, location and coverage. Sometime the data sensed command may ne lost due to congestion, bad connectivity and bit error.

- **Mobility**

In WSAN, nodes are used to reduce the delay, complete the task on time and also distributed failure recovery [1].

II. RELATED WORK

The countless number of studies target upon WSN technology resulting in accurate results. The paper presents the analysis of various methods of data-mining established in the recently. Some of the magnificent researches are as follows:

Abdullah et. al. [1] based on of density grid based clustering for wireless sensor networks WSNs a new clustering method is proposed in this paper. Into grids the network area is divided which are classified as high dense, in the cluster empty grids according to the number of nodes, low dense. To form clusters these grids are combined where empty girds are excluded, in the cluster two adjacent high dense grids are joined, in the cluster two adjacent low dense grid and high dense grid are also joined, and in a cluster two adjacent low dense grids will become as outlier. An appropriate cluster head is determined, as normal nodes and advance nodes cluster nodes are distributed where from the advance nodes with minimum distance to base station the cluster head initially chosen. Based on highest energy the cluster head will be elected. Abdul

Wahid Ali et.al. [2]. For WSN to improve the lifetime of the network a Grid Based Clustering with Spanning Tree Routing (GCSTR) approach is proposed. To the sink all CHs are reported, along specific path i.e. edges of spanning tree. Before construct the spanning tree over CHs whenever evaluate the number of inter transmission and intra transmission, then calculate the lifetime of the network. As compared to LEACH and OCR the simulation result vigorously effect on the lifetime of network. With respect to energy consumption simulation has been done; lifetime of the network over the packets transmits and number of rounds to the sink. Azharuddin, et al. [3] proposed a particle swarm optimization based clustering algorithm in wireless sensor network. The concept of virtual clustering is used during routing process and makes the PSO enables on the network for optimization. In this work control strategy for mobile sink to collect data from cluster head is well designed. The simulation results of this approach show that it reduced the energy consumption, transmission delay and enhance the lifetime of the network. Chen et al. [4] presented a multi-hop routing algorithm which is based on the grid in wireless sensor network. This work is mainly based on reducing and balance the energy consumption on the WSN. The protocol used in this is Grid-based reliable multi-hop protocol it optimizes the cluster head selection by using energy and location of node. The consultative approach is used to balance the energy consumption between cluster heads and their lifetime expectancy. This algorithm reduced the transmission delay among nodes and provides a reliable transmission of data between nodes.

Chien-Fu Cheng et. al. [5] in mobile WSNs the SR problem is revisit in this study. By cascaded movement to faulty sensors and coverage holes the proposed algorithm moves the redundant sensors. In the planning of cascading schedule it is also considers the estimated value of network lifetime. Overall, there are following features of the proposed SR algorithm: longer network lifetime, shorter moving distances, shorter response time and smaller number of requesting places. In all these aspects the performance evaluation done in this research has confirmed its superior performances. Chiang et.al. [6] for grid-based WSNs a Cycle-Based Data Aggregation Scheme is proposed in this paper. By partitioning first construct the grid infrastructure and whole field into a grid of cells to achieve this goal. By a simple arithmetic operation each node is determined which cell it belongs. The cyclic chain formation is easy and its maintenance is also not high. The energy depletion distribute evenly, in each cell the node with most residual energy is chosen to be the cell head. The aggregated data is forwarded of its own cell by only cell head to the leader of cyclic chain. Also to transmit the aggregated data to the BS finally the cell heads on the cyclic chain take turns to be cycle leader. Elhabyan et al. [7] presented the Pareto optimization approach for clustering and routing in the wireless sensor network. The proposed work is based to solve the non-deterministic polynomial hard problems that are routing and clustering. This problem is solved by finding the optimal configuration of the network which is related to the link between the cluster heads, cluster members and their quality link between cluster members. The optimization performed in this work is also called as multi-objective optimization. The proposed protocol is tested on the realistic environment for checking the energy consumption and provides effective throughput. Faheem et al. [8] presented the bird mating optimization process for wireless sensor network in grid applications. The BMO application is used to manage the data traffic and energy consumption between the clusters in smart grid. The proposed approach improves the reliability of the network and reduces the retransmission of the packets in WSN applications. The BMO improves the throughput, packet delivery ratio and reduce the residual energy and memory utilization. Gupta et al. [9] worked on the energy consumption and its optimization in clustering and routing in wireless sensor network. The proposed work is done to resolve the issues of unbalanced energy consumption in clusters. The reason for this problem is due to overloading of sink modes. The cuckoo optimization algorithm is used to balance the energy and uniform distribution of cluster on the wireless sensor network. The harmony search algorithm used to perform the effective routing between the sink and cluster heads. The performance evaluation of the work is done by the changes in energy consumption, total alive nodes on network and lifetime of network and all the metrics shows the significant improvement over existing protocols. Huang, Jianhua, et al. [10] worked on the minimization of energy consumption in the wireless sensor network. The energy-efficient multi-hop routing protocol used to combine the factors like nodes, location, and area of network. The cluster head nodes are selected by using communication nodes and transfer the data between clusters using protocol and reducing the burden of cluster heads. The simulation results shows that this algorithm enhance the network lifetime, balance the energy and efficiency of the network. Jannu et.al.[11] by considering the energy efficiency of the WSN the hot spot problem and present grid based clustering and routing algorithms are addressed in this paper. With various scenarios of WSN the algorithms are tested and in terms of the number of dead sensor nodes, energy consumption and network life time the proposed algorithms perform better than the existing ones by the experimental result.

III. THE PROPOSED METHOD

This chapter describes the detail methodology of the proposed work which includes the algorithm used and flow chart of the work. This work is based on the evaluation of time and energy in the wireless sensor network. The proposed work is mainly based on the grid clustering and optimization approach. The optimization has been performed by using Bacterial Forging algorithm which is based on the biological behavior.

A. Proposed Algorithm

(a) Bacterial Forging Algorithm

Bacterial Forging algorithm is a nature inspired algorithm and based on the behavior of E.coli bacteria. This algorithm provides the multi-optimal function optimization. BFO is based on the chemotaxis behavior of the bacteria. Chemotaxis is basically a process in which bacteria moves by taking small steps in search of nutrients. Following are the steps that follow in BFO.

Chemotaxis: In this process movement of bacteria is performed using swimming and movement of the bacterium represented by

$$\theta^i(p+1,q,r) = \theta^i(p,q,r) + a(i)\frac{\Delta(i)}{\sqrt{\Delta^T(i)\Delta(i)}}$$

Here p, q, r describes the ith bacterium at p chemotactic, q is reproductive, and r is the elimination dispersal.

a(i) is size of step taken in random direction

Δ is unit length vector

Swarming: E.coli arranging them in a travelling ring for nutrient gradient.

Reproduction: In this approach least optimal solution is rejected and effective solution is considered.

Elimination and dispersal: Updated and effective solutions are taken and rest is eliminated.

Step 1: Initialization phase:

Deploy the WSN nodes ← N

Make grid topology.

Step 2: Setup Phase:

Make cluster head with high centrality.

Step 3: Routing Phase:

Decision Routing N(I,j)

1. Initialize BFO ← Distance, Energy.
2. Start reproduction loop, change the parameters.
3. Compute the chemo taxies (Energy reduction).
4. Compute cost function
   If optimize ← yes then go to step 5 otherwise step 1.
5. Analysis Dead node and time

(b) PSO

PSO stands for particle swarm optimization**.** PSO is a stochastic optimization algorithm which is based on the behavior of birds. It works similar to the genetic algorithm. In PSO is initialized with a group of random particles. In every iteration, each particle is updated by the two "best" values. The first best solution shows the fitness of the particles and this called as pbest. The second best value is tracked by the optimizer is the best value. This value is called as global best (gbest).When a particle takes part of the population as its topological neighbors; the best value is a local best and is called lbest.

B. Proposed methodology: Algorithm/Flowchart

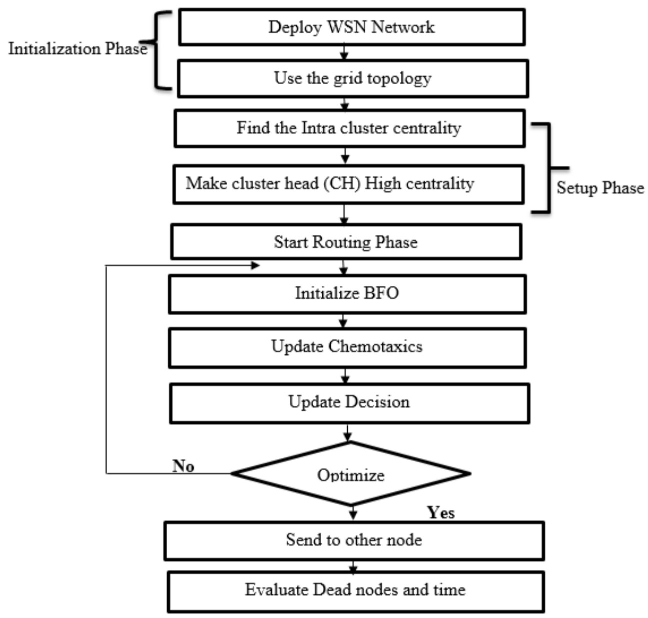

Fig.4 Proposed Flowchart

IV. RESULT ANALYSIS

This analysis presents the result and discussion of the proposed work in the graphical form. These graphs are generated in the simulation environment which is use to evaluate the performance of the proposed work over the existing work. The performance evaluation is done on the basis of below given parameters.

(a) Parameters Used: Parameters are the metrics that are used to evaluate the performance of the proposed methods. In the table different metrics used in the wireless network are shown with their standards.

Table.1 settling physical and wireless parameters

Operation	**Energy dissipation**
Shape of network	Grid/ Square
Area of Implementation	10^4 m^2
Number of Nodes	200
Transmitter/ Receiver	$E_{elec}= E_{tx} = E_{rx} = 50$ nJ/Bit
Data Aggregation	$E_{fs} = 10$PJ/Bit/µ m^4
Transmit Amplifier	Emp = 0.0013 PJ/Bit m^4

(b) Results: The results are illustrated as below:

Table.2 Packet sends to base station

Number of rounds	**Existing**	**Proposed with PSO**	**Proposed with BFO**
0	0	0	0
100	0.2	0.31	0.33
200	0.4	0.60	0.62
300	0.4	0.71	0.72
400	0.4	1.22	1.27
500	0.4	1.5	1.52
600	0.4	1.6	3.2
700	0.4	1.72	1.73
800	0.4	2.1	2.3
900	0.4	2.4	2.39
1000	0.4	2.6	2.7

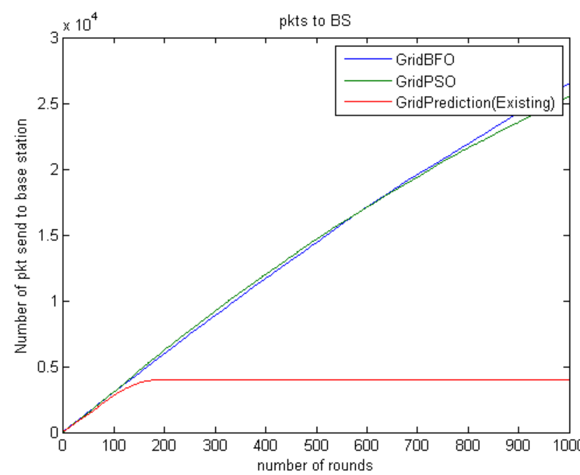

Fig.5 Number of packets sends to the base station

The fig.5 depicts the total number of packets sends to the base station in different number of rounds. The x-axis contains the number of rounds and y-axis contains the number of packet sends. The Red curve shows the packets send by the existing approach, Blue curve shows the packets sends by the proposed approach with BFO and Green curve shows the packets sends by the PSO approach. The outcomes of the curve show that the proposed BFO approach sends the maximum packets to the base station.

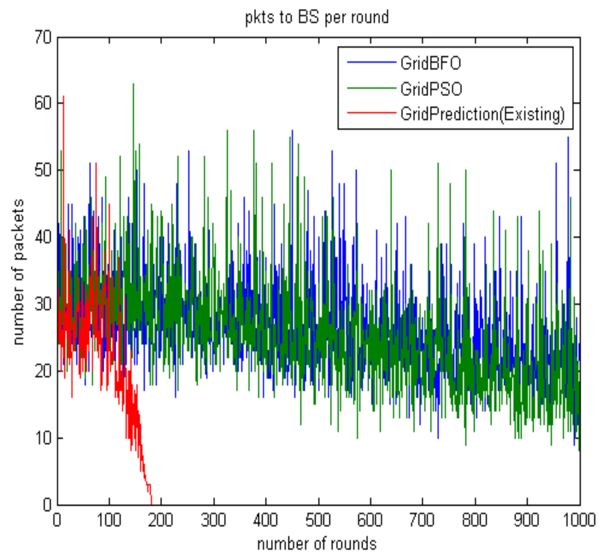

Fig.6 Number of packets sends to the base station

The fig.6 depicts the total number of packets sends to the base station in different number of rounds. The x-axis contains the number of rounds and y-axis contains the number of packet sends. The Red curve shows the packets send by the existing approach, Blue curve shows the packets sends by the proposed approach with BFO and Green curve shows the packets sends by the PSO approach. The outcomes of the graph show that the proposed BFO approach sends the maximum packets to the base station because the occurrence of the blue line frequency is maximum.

Table.3 Packets to Cluster Heads

Number of rounds	**Existing**	**Proposed with BFO**	**Proposed with PSO**
0	0	0	0
100	2	2.2	2.1
200	2.2	3.2	3.1
300	2.2	5.2	5.0
400	2.2	5.7	6.5
500	2.2	7.4	6.2
600	2.2	9.4	7.5
700	2.2	10.2	8.7
800	2.2	11.5	9.8
900	2.2	13.5	10.5
1000	2.2	14	11

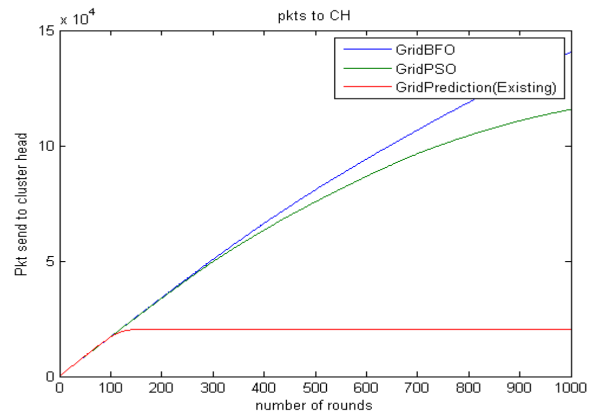

Fig.7 Packets sends to the cluster head

The fig.7 depicts the total number of packets sends to the cluster head in different number of rounds. The x-axis contains the number of rounds and y-axis contains the number of packet sends. The Red curve shows the packets send by the existing approach, Blue curve shows the packets sends by the proposed approach with BFO and Green curve shows the packets sends by the PSO approach. The outcomes of the graph show that the proposed BFO approach sends the maximum packets to the cluster head because the occurrence of the blue line frequency is maximum.

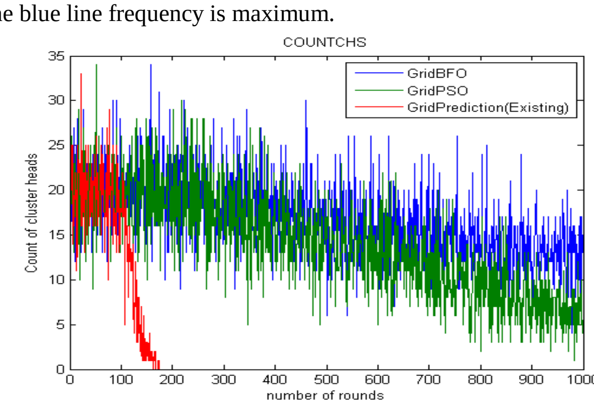

Fig.8 Packets sends to the cluster head

The fig.7 and 8 depicts the data packets sends to the base station in different rounds. The x-axis contains the number of rounds and y-axis contains the number of packet sends. The Red curve shows the packets send by the existing approach, Blue curve shows the packets sends by the proposed approach with BFO and Green curve shows the packets sends by the PSO approach.

Table.4 Throughput of Prediction based, BFO, and PSO

Number of Rounds	Prediction Based	BFO Based	PSO Based
0	0.0	0.0	0.0
100	2.2	2.2	2.2
200	2.2	4.0	4.0
300	2.2	6.0	5.9
400	2.2	7.2	6.8
500	2.2	9.5	8.2
600	2.2	10.5	10.0
700	2.2	12.	11.5
800	2.2	13.9	12.1
900	2.2	14.0	13.5
1000	2.2	17.2	14.1

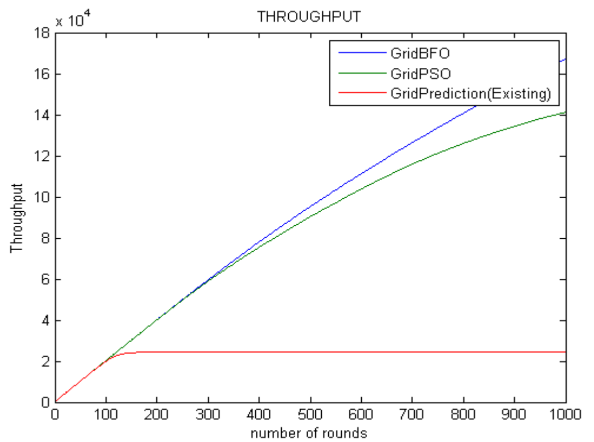

Fig.9 Throughput of the approaches on different rounds.

The fig.9 depicts the throughput of the proposed and existing approaches on different rounds. The x-axis contains the number of rounds and y-axis contains the number of packet sends. The Red curve shows the packets send by the existing approach, Blue curve shows the packets sends by the proposed approach with BFO and Green curve shows the packets sends by the PSO approach. The outcomes of the curve show that the proposed BFO approach sends the maximum throughput.

Table.5 Average Residual Energy of Prediction based, BFO, and PSO

Number of Rounds	Prediction Based	BFO Based	PSO Based
0	98	112	99
50	60	108	93
100	12	102	87
200	00	87	62
300	00	79	51
400	00	73	38
500	00	64	31
600	00	59	25
700	00	54	21
800	00	49	14
900	00	45	9
1000	00	43	7

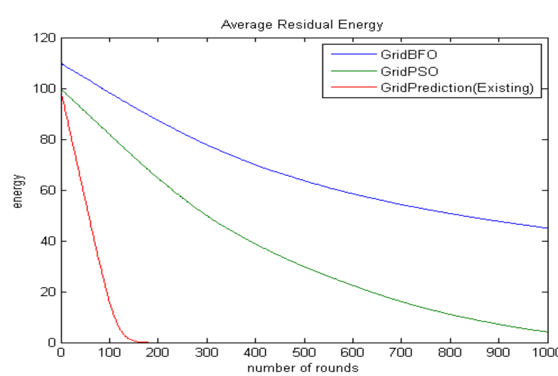

Fig.10 Average Residual Energy of Prediction based, BFO, and PSO

The fig.10 depicts the Average Residual Energy of the proposed and existing approaches on different rounds. The x-axis contains the number of rounds and y-axis contains the number of packet sends. The Red curve shows the packets send by the existing approach, Blue curve shows the packets sends by the proposed approach with BFO and Green curve shows the packets sends by the PSO approach. The outcomes of the curve show that the proposed BFO approach has maximum residual energy in all 1000 rounds.

Table.6 Dead Nodes in of Prediction based, BFO, and PSO

Number of Rounds	Prediction Based	BFO Based	PSO Based
0	00	00	
100	20	00	
200	00	1	1.7
300	00	8	18
400	00	21	41
500	00	38	61
600	00	40	79
700	00	46	94
800	00	56	112
900	00	70	120
1000	00	78	138

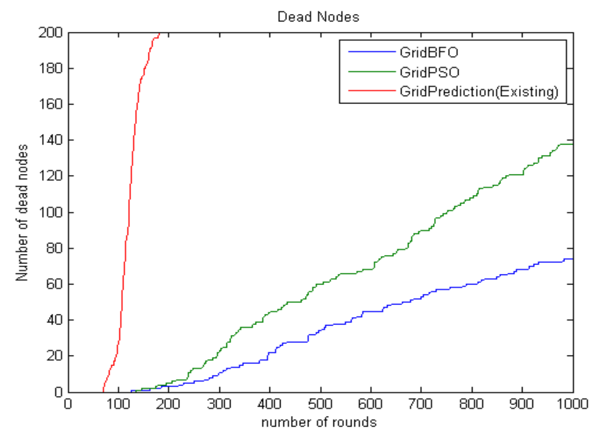

Fig.11 Dead nodes in grid prediction, BFO, and PSO

The fig.11 depicts the Dead Nodes of the proposed and existing approaches on different rounds. The x-axis contains the number of rounds and y-axis contains the number of packet sends. The Red curve shows the packets send by the existing approach, Blue curve shows the packets sends by the proposed approach with BFO and Green curve shows the packets sends by the PSO approach. The outcomes of the curve show that the proposed BFO approach has minimum dead nodes in all 1000 rounds.

V. CONCLUSION

In the above given section graphs and tables presented the result of the grid prediction, grid BFO and grid PSO. The performance evaluation is done on the basis of metrics that are throughput, alive nodes and packets to the base station and cluster heads. The Alive node in the grid BFO is more than the grid prediction and PSO it shows significant results. The throughput of the grid prediction and PSO is low as compare to grid BFO which shows that the BFO gives best prediction result. This study concluded that the BFO performs better as compare to grid prediction.

The dead node in the BFO is less than the Grid prediction and grid PSO which makes it more effective. The average residual energy helps the network more reliable and effective, the proposed BFO prediction has maximum residual energy as compare to grid prediction and P

V. REFERENCES

[1] Abdullah, Manal, et al. "Density Grid-Based Clustering for Wireless Sensors Networks." *Procedia Computer Science* 65 (2015): 35-47.

[2] Ali, Abdul Wahid, Parma Nand, and Rani Astya. "Elongate the lifetime of the network using grid based cluster with backbone spanning tree for wireless sensor networks." *Computing, Communication and Automation (ICCCA), 2016 International Conference on*. IEEE, 2016.

[3] Azharuddin, Md, and Prasanta K. Jana. "PSO-based approach for energy-efficient and energy-balanced routing and clustering in wireless sensor networks." *Soft Computing* 21.22 (2017): 6825-6839.

[4] Chen, Zhansheng, and Hong Shen. "A grid-based reliable multi-hop routing protocol for energy-efficient wireless sensor networks." *International Journal of Distributed Sensor Networks* 14.3 (2018): 1550147718765962.

[5] Cheng, Chien-Fu, and Chih-Wei Huang. "An energy-balanced and timely self-relocation algorithm for grid-based mobile wsns." *IEEE Sensors Journal* 15.8 (2015): 4184-4193.

[6] Chiang, Yung-Kuei, Neng-Chung Wang, and Chih-Hung Hsieh. "A cycle-based data aggregation scheme for grid-based wireless sensor networks." *Sensors* 14.5 (2014): 8447-8464.

[7] Elhabyan, Riham, Wei Shi, and Marc St-Hilaire. "A Pareto optimization-based approach to clustering and routing in Wireless Sensor Networks." *Journal of Network and Computer Applications* 114 (2018): 57-69.

[8] Faheem, Muhammad, and Vehbi C. Gungor. "Energy efficient and QoS-aware routing protocol for wireless sensor network-based smart grid applications in the context of industry 4.0." *Applied Soft Computing* 68 (2018): 910-922.

[9] Gupta, Govind P., and Sonu Jha. "Integrated clustering and routing protocol for wireless sensor networks using Cuckoo and Harmony Search based metaheuristic techniques." *Engineering Applications of Artificial Intelligence* 68 (2018): 101-109.

[10] Huang, Jianhua, et al. "An energy-efficient multi-hop routing protocol based on grid clustering for wireless sensor networks." *Cluster Computing* 20.4 (2017): 3071-3083.

[11] Jannu, Srikanth, and Prasanta K. Jana. "A grid based clustering and routing algorithm for solving hot spot problem in wireless sensor networks." *Wireless Networks* 22.6 (2016): 1901-1916.