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Energy Efficiency Analysis in ERA using NFL-BA Algorithm

Palky Mehta[1], H.L Sharma[2]
[1] M.Tech Sholar, Department of Electronics & Communication Engineering, SSIET Patti, Punjab, India
[2] Professor, SSIET, Department of ECE, Patti, Distt TarnTaran, Punjab, India

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ABSTRACT

In the current scenario of Wireless Sensor Network (WSN), power consumption is the major issue associated with nodes in WSN. LEACH technique plays a vital role of clustering in WSN and reduces the energy usage effectively. But LEACH has its own limitation in order to search cluster head nodes which are randomly distributed over the network. In this paper, ERA-NFL- BA algorithm is being proposed for selects the cluster heads in WSN. This algorithm help in selection of cluster heads can freely transform from global search to local search. At the end, a comparison has been done with earlier researcher using protocol ERA-NFL, which clearly shown that proposed Algorithm is best suited and from comparison results that ERA-NFL-BA has given better performance.

Keywords : WSN, Energy Constraints, BAT Algorithm, LEACH, Routing Protocol.

I. INTRODUCTION

Advances in wireless communication lead to develop wireless sensor networks in which small devices such as nodes and Trans-receive the information among the other nodes. WSN are commonly used in commercial and industrial areas due to its advancement such as environmental monitoring, habitat monitoring, healthcare, monitoring and surveillance [1].

The demand of WSN increases from past to future and at the same time it faces the problem of power limitation such as battery life, operating power of nodes etc. Each node is dependent on operating energy for its functioning. This creates a major issue in network. The failure of functioning any node creates problem to the entire system or application. Every sensing node can be operated at various mode of operation such as active, idle and sleep modes. In active mode state, nodes are able to consume energy while receiving or sending the data. In idle mode, the nodes utilize the same energy as in active mode, while in sleep mode, the nodes stop to send & receive the information and save the radio waves [2].

The following steps are being taken in order to save energy while functioning in wireless sensor networks [3].

- To arrange the periodic Ways for data sending, receiving by nodes at various mode of operation.
- The range of transmission is adjustable between the communicating sensing nodes.
- An efficient routing
- An efficient routing pattern and data collecting methods has been used.

- Avoid the Data which is required for overhearing.

In a wireless sensor network there are two types of protocols such as Routing protocols and Medium Access Control (MAC) protocols which are used to handle the communication process between the nodes. In basic communication system, periodic data send is considered or at the time of requirement of data are being utilize from base station or from sink. So the multicasting and broadcasting capabilities are required. Routing protocols has played a vital role in fulfilling the requirements of energy conservation and also imphasis on performance of the system like Quality of Service (QoS) at some level [4].

1. Problem Formulation

Many LEACH improvements techniques have been used [5], which reduces the utilization of energy in the LEACH protocol. Earlier researches were based on head node selection. A new modified protocol had used the implementation of cluster-head multi-hop algorithm which is based on LEACH for finding the optimal path between cluster-heads & base station [6]. A simulated annealing algorithm with LEACH protocol had proposed for select the cluster-head node in WSNs, demonstrating much better performance compared with the original protocol [7]. An improved routing protocol called ANT-LEACH was proposed in which adopted the strategy of combining an ant colony optimization algorithm and the routing process of cluster-head nodes [8,9]. ERA-NFL is a Distributed Energy -Efficient Clustering protocol which is based on neural based approach that utilized grouping with fuzzy logic. The fuzzy logic used in ERA-FL is based on sugani model in which neural approach has been applied. It is based on energy dissipation during cluster head selection [10]. A new intelligent optimization algorithm has proposed in which the bat algorithm (BA), by simulating the echolocation behaviour of bats [11,12]. The algorithm is a population-based stochastic optimization algorithm of which bat individuals are the basic units. The movement of the entire population produces an evolutionary process from disorder to order in the problem-solving space, thereby obtaining the optimal solution. A complex-valued BA proposed, where each bat is coded with a complex number [13]. A fast BA with triangle-flipping strategy (FTBA) has presented in which increased the global search ability of the algorithm [14]. Despite these achievements, most methods are based on a predefined searching pattern or deterministic optimization algorithms. To identify a better energy-saving solution, superior optimization of cluster-head node selection is required.

2. Routing Protocols for WSN Networks

Routing protocols have a large scope of research work when implemented in a WSN, because the functioning of these protocols depends upon the type of network structure designed for the application or the network operations carried out using these protocols for a specific application model. Figure 1 shows the protocol classification or routing taxonomy for routing protocols which are further sub-divided into subcategories. A brief introduction of each category is given below [16].

2.1 Structure Based Routing Protocols Routing protocols are divided into structure-based routing protocols, which are in turn classified as flat routing, hierarchical routing and location-based routing. The protocols which fall under these categories work with respect to the design constraints given for the network structure or area.

2.2 Flat Routing

In this routing technique, all the sensor nodes play the same roles, such as collecting data and communicating with the sink, i.e. all the data collected in the remote area can be same or

duplicated as all the sensor nodes work in the same way [17]

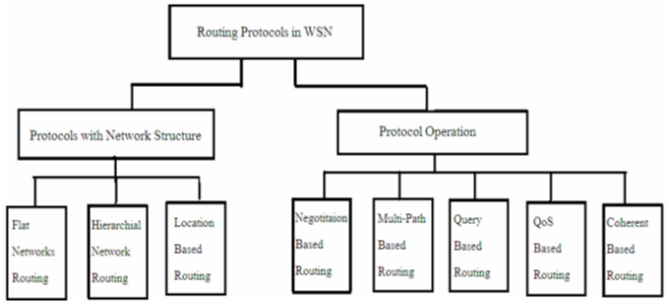

Figure 1. Routing Protocols in Wireless Sensor Networks

3. CLUSTERING IN WSN

Clustering is the techniques which combined the same functioning object in set. Many researchers are using clustering technique for selection of cluster head node. Nodes are classified in primary and secondary nodes in clustered WSN system. The data aggregation and data processing process function is involved in primary nodes whereas secondary nodes is only performed the task of data forwarding. Clustering save & increases the network energy and scalability. A distributing load technique is used for making good decision for selecting cluster head in order to save energy. Nodes having high energy are considered as load thus increasing the lifetime of the network. A minimum distance has been travelled by nodes between the cluster head and base stations in clustering. Only cluster heads communicates with cluster head thus reduces the data redundancy which usually happened when each node perform its own data aggregation and transmission [8] function separately. This algorithm provides very efficient way of communication in sensor networks. Such algorithm creates easy to maintain power saving algorithms. Clustering in WSN network makes them suitable for use in uneven environments.

4. TYPES OF CLUSTERING ALGORITHMS

Event-to-Sink Direct Clustering is another type of protocol which provides high efficiency in terms of energy consumption. When a node discovers an event, it sends its report to the sink. A sensor node sends this collected data to the cluster head thus avoiding redundancy. This technique provides two new improvements:

1. Clustering is only performed when an event occurs, so no unnecessary clustering rounds need to perform.
2. There id minimum movement of data in the cluster because clusters are formed in the direction from event sinks.
3. Cluster heads are selected from up-stream nodes and non-cluster nodes are selected from downstream nodes.

(A) Genetic Algorithms : Genetic algorithm is technique that used to find the optimally allocate for the server within the cluster. A combination of similar servers is termed as Cluster. Multiple Clusters when combining together form Grid [19].

(B) Ant Colony Optimization: Ant colony optimization is a novel approach that was introduced by Dorigo in the year 1992 during his Ph.D. thesis and in original this was named as ant system. The ant colony optimization algorithm is based on the behavior of real ants. As ant find their shortest path between their source of food and colonies. Similarly, this algorithm also works on the same principles. The ants usually release a chemical substance known as pheromone while walking from their colonies to the source of food. As the path on which more pheromones are released is considered as the shortest path by the ants. The more pheromone released means the number of ants traveled from that path. This method is more useful for solving the discrete optimization problems that need to find path for their specific goals [21].

(C) Honeybee Algorithm : This algorithm has better features than the Ant Colonies algorithm along with high distance capabilities. This algorithm utilizes optimal pathfinding along with distance coverage. It utilizes the nose around that associated with honey bees to find the right path out of alternatives available [20].

(D) Cuckoo Algorithm : Cuckoo is a meta-heuristic algorithm inspired by the bird cuckoo; these are the Brood parasites birds. It never builds its own nest and lays its eggs in the nest of other host bird nest. Cuckoo is a best-known brood parasite. Some host birds can employ directly with the intruding cuckoo. If the host bird identifies the eggs that are not their own egg then it will either throw that eggs away from its nest or simply rid its nest and build a new nest [21].

(E) BAT Algorithm

Bat Algorithm was introduced by Yang in the year 2010 based on the echolocation behavior of Bats. To estimate the distance of prey, the bat used echolocation to sense the distance. The BAT algorithm is totally based on the behavior of BATs. The BATs usually fly randomly with a frequency, loudness, pulse emission, velocity and position to search for their prey. When the BATs hunt for the prey, they automatically adjust their parameters like velocity, frequency, loudness and pulse emission based on the distance among them and the prey [18].

II. MATHEMATICAL MODEL

BA is a heuristic intelligent algorithm that simulates the principle of echolocation used in bat predation. BA has passed standard test functions and achieved good results for solving continuity optimization problems [18,19]. In the next generation, the velocity is represented as follows in n virtual distribution of Bats:

$$v_{it}(t+1) = v_{it}(t) + ([x_{it}(t) - P_k(t)]).f_i(t)$$

where $v_{it}(t)$ is the inertia, $x_{it}(t)$ is the various position, $P_k(t)$ best position find in the system. The frequency $f_i(t)$ is calculated as follows:

$$f_i(t) = f_{min} + (f_{max} - f_{min}) * rand$$

where and f_{max} are the maximum and f_{min} minimum frequency values, respectively, and rand is a random number uniformly distributed within [0,1]

The bat Algorithm decision predicts the position changes with some randomness. Let be a new random number uniformly distributed within [0, 1]; if new random number $r_{new}(t) < r(t)$ is satisfied, then the bat will execute the following global position search pattern:

$$x_i(t+1) = \begin{cases} x_i'(t+1) \; if \; rand\; new1 < A_i(t) and \; f x_i'(t+1) < f(x_i(t) \\ x_i(t) \qquad\qquad otherwise \end{cases}$$

$$x'_{ik}(t+1) = P_k(t) + \beta_{ik} * A_{av}(t)$$

$$x'_{ik}(t+1) = x_{ik}(t) + v_{ik}(t+1)$$

$$T(s) = p_{opt}/(1 - p_{opt}\left(r_{\,mode}\frac{1}{p_{opt}}\right)$$

Where $rand\; new1\; is$ random number generated by uniform distribution within the range [0,1], $A_i(t)$ is the loudness value of the bat, β_{ik} is the random number generated by uniform distribution with in the range of [-1, 1] and $A_{av}(t)$ is average value of loudness, T(S) is the threshold value for the cluster head selection.

During selection, firstly, temporary cluster-head is generated, the average energy in clusters is calculated, and then intelligent algorithm ERA-NFL-BA has been used to find the best position in the cluster. If

the temporary node's energy is more the average energy, the node becomes the official head node and broadcasts the identity message; if the node energy is lower than the average energy, the algorithm waits for an official node. This process loops until all clusters are complete, and then the protocol enters the ready phase.

III. RESULT AND DISCUSSION

To measure the performance of the proposed routing protocol, the simulation of the network field of (100*100)m was performed. The arrangement of the WSN nodes was such like that the sink was in centre and other 100 connected nodes were deployed randomly. The simulation for the proposed ERA-NFL-BA was performed at initial energies with packet size of 2000 bits. The performance of the network was evaluated in terms of stability Period, Network Lifetime, Number of Packets sent to cluster, throughput to the base station and Remaining Energy. All the simulation parameters were presented in Table 3.2. At initial energy of 0.5 J & probability 0.1 have been taken for getting simulation results.

Table 1 : Parameters used for Simulation

S. No.	Parameters	Value
1	Number of nodes	100
2	Network field	(100,100)m
3	Message size	2000 bits
4	E_o(Initial Energy)	0.5J
5	E_{elec}	50nJ/bits
6	E_{amp}	0.0013 pJ/bit/m^2
7	E_{fs}	10 nj/bit/m^4
8	EDA	5 nJ/bits/signal
9	Do (Threshold)	70m
10	Bandwidth	1Mbps

With another variant in the initial energy, the simulation of the proposed algorithm with 100 nodes was performed on initial energy of 0.5 and with probability of 0.1. The simulation results were presented in Figure 2- Figure 7. It was found that the first dead node was at 1357th round and death of the last node occurred 2149th round as presented in Figure 2 and Figure 4. The residual energy of the network lasted up to 2147 rounds with maximum throughput as presented in Figure 5.

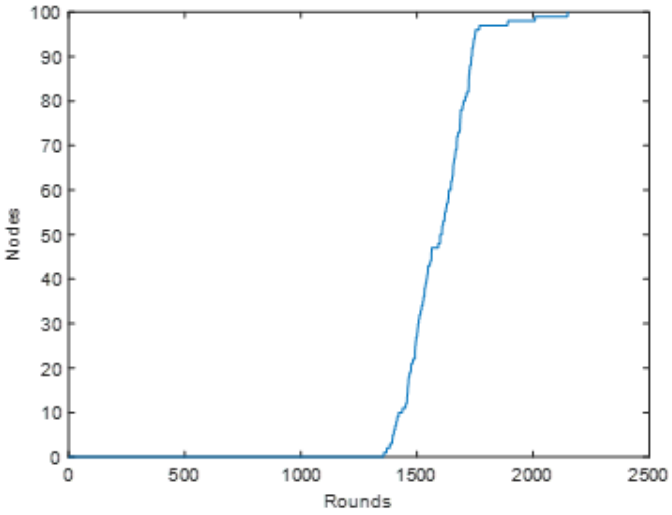

Fig. 2 : Stability Period at IE = 0.5J

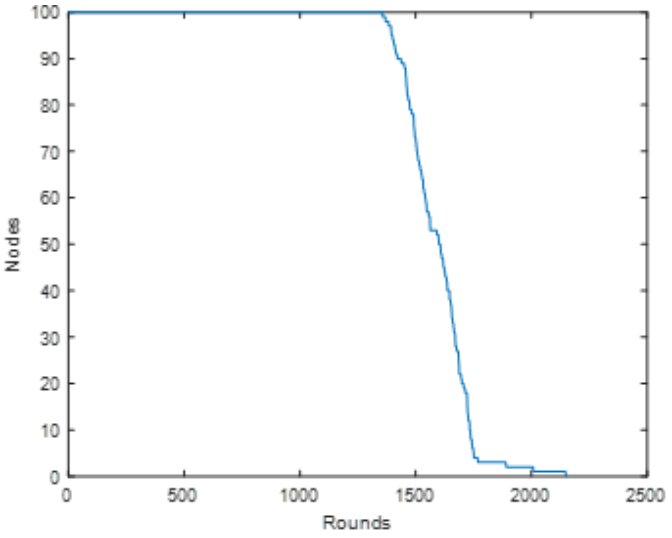

Fig. 3 : Network lifetime at IE = 0.5J

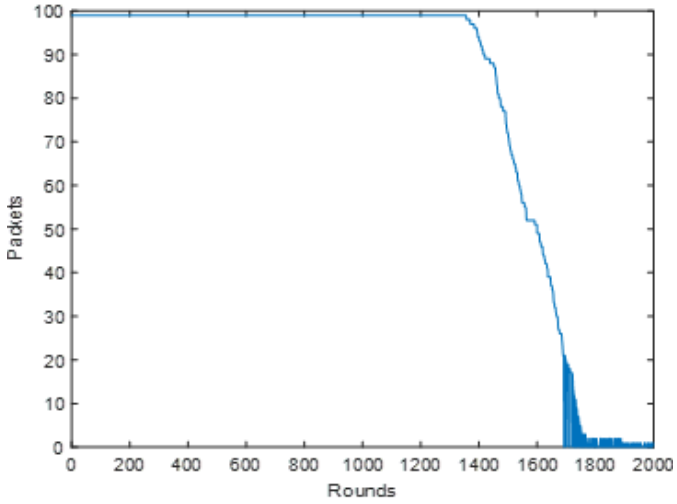

Fig. 4 : Number of Packets sent to Cluster Head at IE = 0.5J

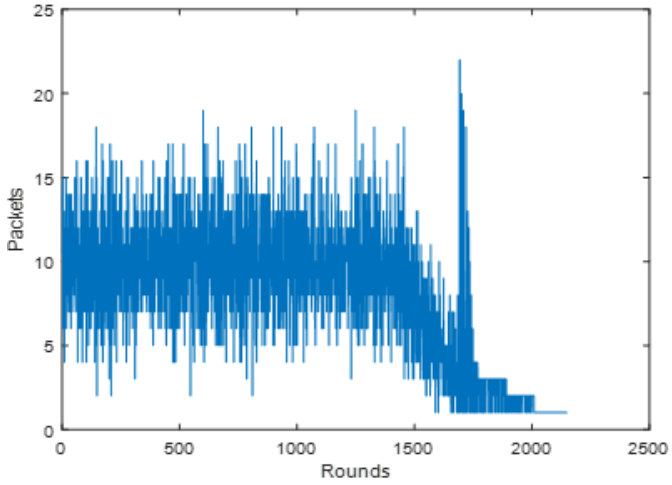

Fig. 5 : Throughput to the base station at IE =0.5J

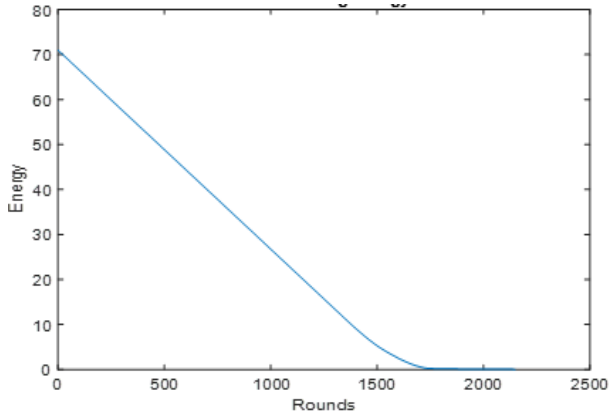

Fig. 6 : Remaining Energy at IE = 0.5J

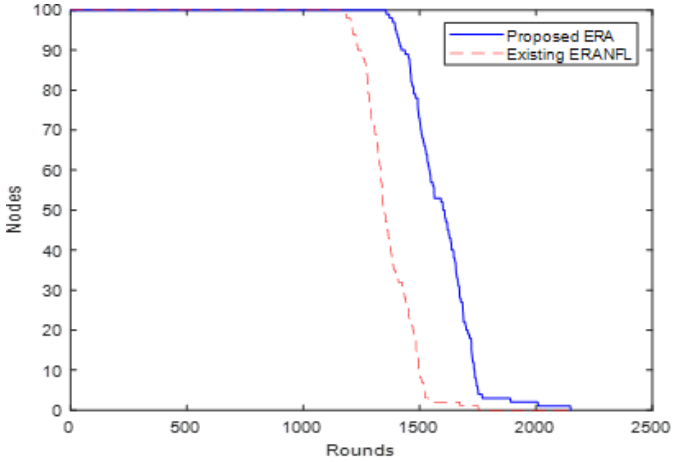

Fig. 7 : Stability of the network at IE=0.5J.

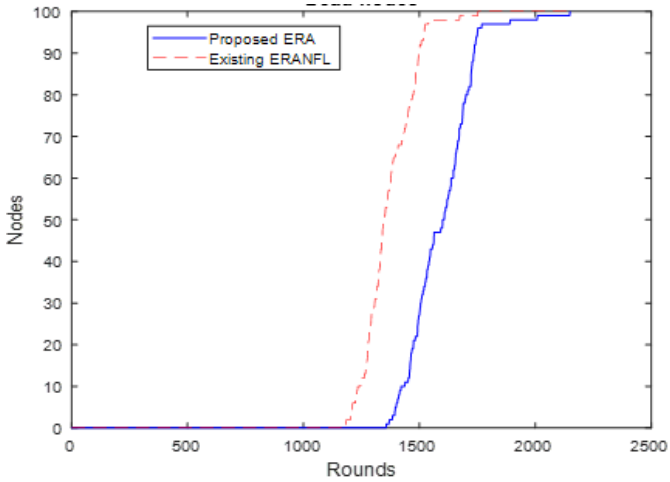

Fig. 8 : Lifetime of the network at IE=0.5J.

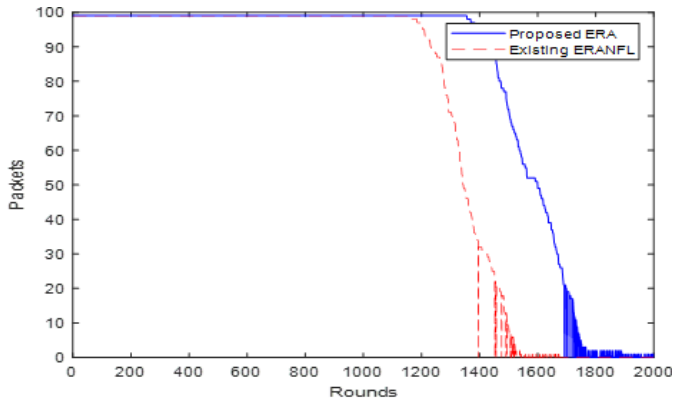

Fig. 9 : Packets sent to Cluster Head at IE=0.5J.

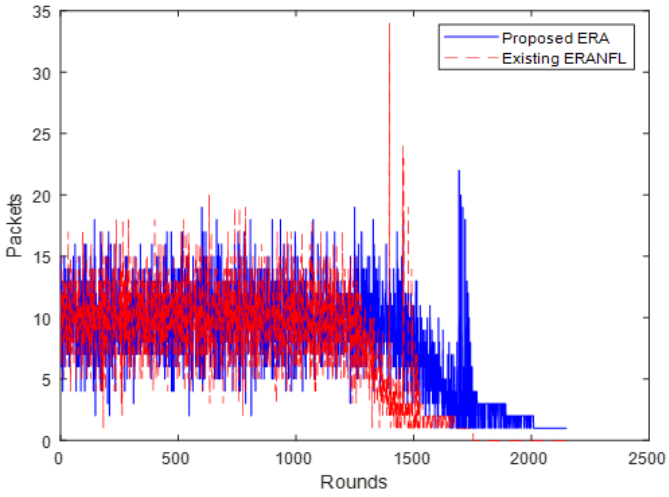

Fig. 10: Throughput of the network at IE=0.5J.

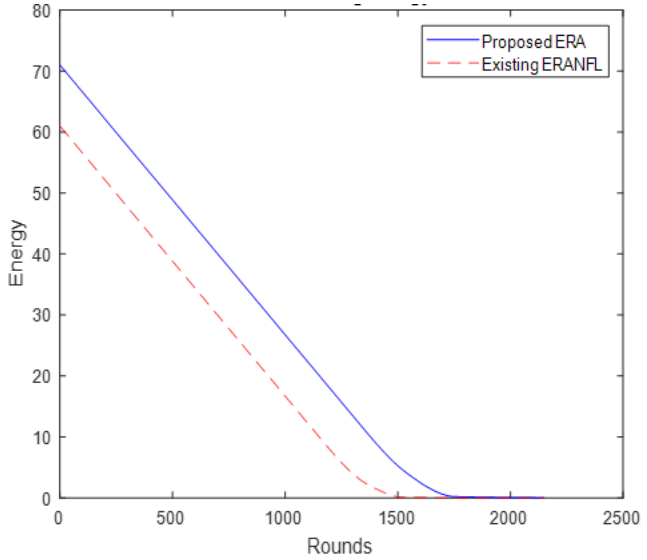

Fig. 11 : Remaining energy at IE=0.5J.

The comparison of the proposed routing algorithm with the existing algorithms ERA-NFL and proposed Algorithm (ERA-NFL-BA) was performed through simulations. It was observed that the proposed algorithm performed better than ERA-NFL algorithm at tested initial energies. The optimized results were found at the initial energy of 0.5J in terms of stability, network lifetime, throughput, No of packet sent of CH and remaining energy of the network as shown in figure (8-12). A comparison table of proposed Algorithm over the Earlier Worker [10] has been presented for showing the performance.

Parameters	Initial Energy =0.5J	
	Existing ERA-NFL	Proposed ERA-NFL-BA
First Node Dead	1163	1357
Network Life Tim	1754	2149

IV. CONCLUSION

WSN consists of hundreds of low power nodes with multiple functions, then routing and the issue of energy constraint is significance. The proposed protocol called ERA-NFL-BA, which can distribute workload and enhance the stability of sensor network by optimally electing cluster heads using BAT algorithm. The performance of the proposed algorithm is evaluated through stability of the network, network lifetime, throughput of the network and number of packets sent to cluster head.

V. REFERENCES

[1]. Romer, Kay, Friedemann Mattern, "The Design Space of Wireless Sensor Networks" IEEE Wireless Communications, Dec. 2004.

[2]. M. Chu, H. Haussecker, and F. Zhao, "Scalable Information-Driven Sensor Querying and Routing for ad hoc Heterogeneous Sensor Networks", The International Journal of High Performance Computing Applications, Vol. 16, No. 3, August 2002.

[3]. K. Khalid, I. Woungang, S. K. Dhurandher, L. Barolli, G. H. S. Carvalho, and M. Takizawa, "An Energy-Efficient Routing Protocol for Infrastructure- Less Opportunistic Networks,"

2016 10th Int. Conf. Innov. Mob. Internet Serv. Ubiquitous Comput., pp. 237–244, 2016

[4]. M. A. Zu-Chang, Y. N. Sun, and T. Mei, "Survey on wireless sensors network," Journal of China Institute of Communications, vol. 20, no. 7, pp. 1737-1880, 2004.

[5]. S. Sharma and M. Kumar, "LEACH PROTOCOL: A Survey," International Journal of Computer Science & Communication Networks, vol. 5(4), pp. 228-232, 2015.

[6]. H. U. Gang, D. M. Xie, and W. U. Yuan-Zhong, "Research and Improvement of LEACH for Wireless Sensor Networks," Chinese Journal of Sensors & Actuators, vol. 20, no. 6, pp. 1391-1396, 2007.

[7]. V. Potdar, A. Sharif, and E. Chang, "Wireless Sensor Networks: A Survey," in Proc. of International Conference on Advanced Information Networking and Applications Workshops, pp. 636-641, 2009.

[8]. J. L. L. K. G. Y. T. Zhang, "Ant colony optimisation for the routing problem in the constellation network with node satellite constraint," International Journal of Bio-Inspired Computation (IJBIC), vol. 10, no. 4, pp. 267 - 274, Nov 2017

[9]. J. Shang, C. Liu, K. Yue, and L. I. Lin, "The Multi-Agent Bat Algorithm Applied to Wireless Sensor Networks," Chinese Journal of Sensors and Actuators, vol. 9, pp. 1418-1424, 2015.

[10]. Tiwari, T., & Roy, N. R. (2015). Modified ERA-FL: A gvarying power level based clustering technique for WSNs. 2015 International Conference on Computer and Computational Sciences, ICCCS 2015, 170–176.

[11]. X. S. Yang, "A New Metaheuristic Bat-Inspired Algorithm," Nature Inspired Cooperative Strategies for Optimization (NICSO 2010), vol. 284, pp. 65-74, 2010.

[12]. M. Chu, H. Haussecker, and F. Zhao, "Scalable Information-Driven Sensor Querying and Routing for ad hoc Heterogeneous Sensor Networks", The International Journal of High Performance Computing Applications, Vol. 16, No. 3, August 2002.

[13]. L. I. Zhi-Yong, M. A. Liang, H. Z. Zhang, and S. O. Management, "Application of Bat Algorithm in Multi-Objective and Multi-Choice Knapsack Problem," Computer Simulation, vol. 30, no. 10, pp. 350-353, 2013.

[14]. X. Cai, H. Wang, Z. Cui, J. Cai, Y. Xue, and L. Wang, "Bat algorithm with triangle-flipping strategy for numerical optimization," International Journal of Machine Learning & Cybernetics, vol. 9, no. 2, pp. 199-215, 2017.

[15]. Xingjuan Cai1, Youqiang Sun1, Zhihua Cui1, Wensheng Zhang2 and Jinjun Chen, " Optimal LEACH Protocol with Improved Bat Algorithm in Wireless Sensor Networks", KSII Transactions On Internet And Information Systems Vol. 13, No. 5, May 2019.

[16]. K. Akkaya and M. Younis, "A survey on routing protocols for wireless sensor networks," Ad Hoc Networks, vol. 3, no. 3, pp. 325-349, 2005.

[17]. Meenakshi, Harjit Pal Singh, Priya Sachdeva, "Performance Analysis of ERA Using Neuro Fuzzy in wireless sensor network", JETIR July 2018, Volume 5, Issue 7, PP 930-937.

[18]. Chuan-Ming Liu, Chuan-Hsiu Lee, Power Efficient Communication Protocols for Data Gathering on Mobile Sensors Networks, IEEE, pp. 4635-4639, 2004.

[19]. Bao, Fenye, Ray Chen, Moon Jeong Chang, and Jin-Hee Cho. "Hierarchical trust management for wireless sensor networks and its applications to trust- based routing and intrusion detection." IEEE transactions on network and service management vol.2 pp: 169-183, 2012.

[20]. Ren, Fengyuan, Tao He, Chuang Lin, and Sajal K. Das Ren. "EBRP: energy-balancing routing protocols for data gathering in wireless sensor

networks." IEEE Transactions on Parallel and Distributed Systems, vol. 12,pp: 2108-2125, 2011.

[21]. Barfunga, SonamPalden, Prativa Rai, and Hiren Kumar Deva Sarna. "Energy efficiency cluster based routing protocol for Wireless Sensor Networks." In Computer efficient clustering based routing protocols for Wireless Sensor Networks." In computer and communication Engineering (ICCCE), International Conference .pp; 603-607., 2012.

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