IJDACR
ISSN: 2319-4863

International Journal of Digital Application & Contemporary Research
Website: www.ijdacr.com (Volume 8, Issue 11, June 2020)

Artificial Bee Colony Algorithm based Optimized Cluster Head Election

Pooja Agrawal
M. E. Scholar
Dept. of Electronics & Communication
IPS Academy, IES Indore, M.P. (India)

Prof. Angeeta Hirwe
Associate Professor
Dept. of Electronics & Communication
IPS Academy IES, Indore, M.P. (India)

Abstract –**Thanks to the great steps taken in recent years in technological development, and in particular microelectronics and wireless communication techniques, small networked and inexpensive communicating sensors are increasingly being used in industrial applications and observation of the environment. However, the use of wireless sensor networks in such applications has to face several limitations imposed by sensors such as processing capacity, small memory size and energy. Or the limits imposed by the network itself, such as the narrow bandwidth, the network dynamics due to the topological variation of the network and the appropriate communication protocols adapted to this type of network. In this paper, we test Low-Energy Adaptive Clustering Hierarchy (LEACH) and Artificial Bee Colony optimized LEACH based cluster head election under a few distinctive situations holding high level heterogeneity to low level heterogeneity. The performance comparison metrics are; network lifetime and network throughput.**

Keywords – **ABC, LEACH, Sensor Nodes, Wireless Sensor Networks.**

I. INTRODUCTION

WSN consist of large number of sensor nodes that are deployed in the environment and are powered by battery and replacing the battery of each and every node in the sensor network is impractical so it is necessary to make use of this limited energy efficiently therefore an energy efficient algorithm has to be designed [1]. The nodes in the WSN are distributed spatially and to send the sensed data to the base station or sink node needs multi-hop communication when the base station or sink is not in range so the number of intermediate nodes are required to send this sensed data to the desired destination which consumes more energy of the network because all the intermediate nodes forward the data coming from their neighbour and to do this job they consume energy and this motivate us to reduce the number of hops and intermediate nodes taking part in transmission of data by using clustering algorithm in which the nodes are grouped into clusters and each node in cluster send data only to their concerned cluster head which is then aggregate all the data coming from the member nodes and send it to the sink or base station [2].

The energy efficient nature, data aggregation, load balancing, and improved network lifetime of hierarchical cluster based routing motivate us to use them for this research [3]. These protocols are centralized or distributed depends on the process of selecting cluster heads. The location of each and every node in the cluster and their residual energy are used to make decision for selecting one of them as a cluster head one such protocol is LEACH [4]. The LEACH protocol is chain based protocol in which each node communicates only with its previous and next neighbour and reduces the number of communicating nodes which helps in reducing energy consumption [5].

Although there is a drawback of using fixed cluster head because all the data of member nodes are routed through the cluster head which lead to higher energy consumption at cluster head and due to this reason they die soon but it will also improve the life time of the network. Increasing the size of cluster head or providing more power as compared to the member node will increase their lifetime. Hence to increase the lifetime of the network and to make it energy efficient the best approach is hierarchical based clustering [6].

Wireless sensor network composed of numerous of sensor nodes which communicate with each other through wireless network. Each sensor node is required to be capable of sensing, processing and communicating the processed data to the neighbouring nodes to form a network. The data packets travel through these sensors nodes from source node to destination node via several intermediate nodes. The data packets can uses long as well as short route to reach to the destination node. The long route may results in network delay

IJDACR
ISSN: 2319-4863

IJDACR
International Journal Of Digital Application & Contemporary Research

International Journal of Digital Application & Contemporary Research
Website: www.ijdacr.com (Volume 8, Issue 11, June 2020)

and can take larger time while simulating it. On the other hand short route results in better network performance by consuming lesser energy and lowest network delay. Finally, the routing targets are oriented by the application, therefore different routing protocols have been offered for easily accessibility of those applications [7].

Wireless sensor network also termed as distributed sensor nodes network in which each node are independent of each other and can perform transferring of data packets individually. A wireless sensor network is an accumulation of small randomly dispersed devices. Moreover in WSN, each node communicates with their neighbour node for transferring data from source node to sink node [8]. The size of sensor nodes may change from small grain size to large box according to the requirement of application. Networking topologies may also vary. In WSN assumption, a user may retrieve the information by sending query to the system and then getting the results accordingly.

We perform an investigational comparison among Low-Energy Adaptive Clustering Hierarchy (LEACH) and Artificial Bee Colony optimized LEACH based cluster head election, so as to find a method which increases the lifetime and reduces the energy consumption of the network.

II. Proposed Methodology

A. Low-Energy Adaptive Clustering Hierarchy (LEACH)

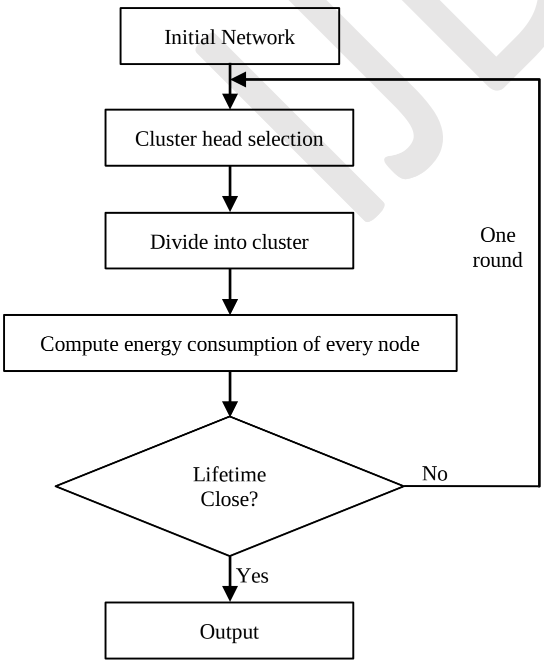

Figure 1: Flow chart for LEACH protocol

During the configuration phase, randomly generated cluster head, the random number is selected in a range between 0 and 1 in each sensor node, if the selected number is smaller than some threshold $T(n)$, then the node is selected as the head of the cluster. Formulas of $T(n)$ as follows [9]:

$$T(n) - \int_0 \frac{p}{1-p\left[r \bmod \left(\frac{1}{p}\right)\right]} \text{ with } n \in G \tag{1}$$

Where, p is the percentage of the number of cluster headers and the total number of nodes in the network, r is the number of the current round, G is the set of cluster nodes except the cluster head of the last rounds $\frac{1}{p}$. Then, the header node of the cluster transmits the message that it is becoming a cluster head in the entire network, each node decides to join that cluster according to the intensity of the received information and responds to the corresponding cluster header. Then, in the next phase, each node uses the TDMA method to transmit data to the cluster header node, the cluster head sends the fusion data to the receiving node. Among the clusters, each cluster competes with the communication channel with the CDMA protocol. After a period of stable phase, the network enters the next round of the cycle again, continuous cycle.

The randomly selected group header method avoids excessive power consumption, improves network life, data fusion reduces traffic effectively, but the protocol still uses jump communication, although the transmission delay it is small, the nodes require high power communications, the expansion is deficient, it is not suitable for large scale networks; even in smaller networks, the nodes furthest from the receiving node communicating with each other at high power can lead to a shorter survival time; frequent selection of the cluster head will lead to the cost of energy traffic.

B. ABC Optimized Cluster Head Election Probability

Let n_{alive} represents the number of alive nodes with residual energy greater then the threshold energy and p be the clusterhead election probability, then the optimum number of CH elected for a given round will be [10]:

$$P_{opt} = n_{alive} * p \tag{2}$$

Here P_{opt} is optimized using Artificial Bee Colony (ABC) optimization, which is described as:

1) Artificial Bee Colony (ABC) Algorithm

The ABC algorithm is a swarm based, meta-heuristic method based on the foraging behaviour of honey bee colonies. The model is composed of three important elements: employed and unemployed foragers, and food sources. The employed and

IJDACR International Journal Of Digital Application & Contemporary Research

International Journal of Digital Application & Contemporary Research
Website: www.ijdacr.com (Volume 8, Issue 11, June 2020)

unemployed foragers are the first two elements, while the third element is the rich food sources close to their hive. The two leading modes of behaviour are also described by the model. These behaviours are necessary for self -organization and collective intelligence: recruitment of forager bees to rich food sources, resulting in positive feedback and simultaneously, the abandonment of poor sources by foragers, which causes negative feedback.

2) Artificial Bee Colony: Procedure

The procedure of ABC could be described in the following seven steps:

1. Initialization of ABC and Optimization Problem Parameters

In general, optimization problem could be formulated as follows:

Where $f(x)$ is the objective function to be minimized; x is the set of decision variables $\{x_i \mid i = 1, \dots, N\}$. X is the possible range for each decision variable, where $X = \{X_1, X_2, \dots, X_N\}$ and $X_i \in (LB_i, UB_i)$ and LB_i and UB_i are the lower and upper bound values for the variable x_i. N represents the number of decision variables and, $g(x)$ and $h(x)$ are the inequality and equality constraints, correspondingly.

Additionally, ABC consists of three control parameters:

a) Population size (SN) is the number of food sources (or solutions) in the population. SN is equal to the number of employed bees or onlooker bees.
b) Maximum Cycle Number (MCN) refers to the maximum number of generations.
c) The limit is used to diversify the search, to determine the number of allowable generations for which each non-improved food source is to be abandoned.

2. Initialization of the Food Source Memory (FSM)

The Food Source Memory (FSM) is an augmented matrix of size $SN \times N$ comprised in each row, a vector representing a food source as in equation (4.5). Note that the vectors in the FSM are sorted in ascending order, according to proximity cost function values.

$$FSM = \begin{bmatrix} x_1(1) & x_1(1) & . & x_1(1) \\ x_2(2) & x_2(2) & \vdots & x_2(2) \\ \vdots & \vdots & \vdots & \vdots \\ x_{SN}(1) & x_{SN}(1) & \cdot & x_{SN}(1) \end{bmatrix} \begin{bmatrix} f(x_1) \\ f(x_2) \\ \vdots \\ f(x_{SN}) \end{bmatrix} \quad (3)$$

Generally, each vector is generated as follows:

$$x_j(i) = LB_i + (UB_i - LB_i) \times r$$
$$\forall_j \in (1,2,\dots,SN), \forall_i \in (1,2,\dots,N) \quad (4)$$

Note that $r \sim (0,1)$ generates a uniform random number between 0 and 1.

3. Assigning Employed Bees to the Food Sources

In this step, each employee bee is assigned to its food source and in turn, a new one is generated from its neighbouring solution, using equation (5) as is shown algorithm 1:

$$x'(i) = x_j(i) \pm r\left(x_j(i) - x_k(i)\right)$$
$$\forall k \in (1,2,\dots,SN) \;\; k \neq j and\; r \sim (0,1) \quad (5)$$

Algorithm 1: Employed Bee Phase

1. $for\; j = 1,2,\dots,SN\; do$
2. $for\; i = 1,2,\dots,SN\; do$
3. $x'(i) = x_j(i) \pm r\left(x_j(i) - x_k(i)\right)$
   $\forall k \in (1,2,\dots,SN) \;\; k \neq j and\; r \sim (0,1)$
4. end
5. $calculate\; f(x_i)$
6. $if\; \left(f\,(x') \le f(x_i)\right)\; then$
7. $x_i = x'$
8. $f(x_i) = f\,(x')$
9. $end\; if$
10. $end\; for$

4. Sending the Onlooker Bees

The onlooker bee has the same number of food sources as the employed. It initially calculates the selection probability of each food source generated by the employed bee in the previous step. The fittest food source is selected by the onlooker, using Roulette Wheel selection mechanism. The process of selection at the onlooker phase works as follows:

1. assign for each employed bee a selection probability p_j as follows:

$$p_j = \frac{f(x_j)}{\sum_{k=1}^{SN} f(x_k)} \quad (6)$$

2. The food source of the employed bee with the highest fitness is selected by the onlooker bee, based on its selection probability and adjusted as shown in the algorithm (2).

In the algorithm, sum_prob is the accumulated probability of all the employed bees; where the sum_prob of solution x_j; $\{j = 1,2,\dots,SN\}$ is unity

Algorithm 2: Onlooker Bee Phase

1. $for\; i = 1,2,\dots,SN\; do$
2. $r \sim (0,1)$
3. $sum\_prob = 0$
4. $j = 0$
5. $while\; (sum\_prob \le r)\; do$
6. $sum\_prob = sum\_prob + p_j$
7. $j = j + 1$
8. $for\; i = 1,2,\dots,SN\; do$

IJDACR
International Journal Of Digital Application & Contemporary Research

International Journal of Digital Application & Contemporary Research
Website: www.ijdacr.com (Volume 8, Issue 11, June 2020)

9. $x\prime(i) = x_j(i) \pm r\left(x_j(i) - x_j(m)\right) \quad \forall m \in (1,2,..,SN)$
10. $end\ for$
11. $calculate\ f(x_j)$
12. $if\ \left(f\ (x\prime) \leq f(x_j)\right)\ then$
13. $x_j\ =\ x\prime_j$
14. $f\ (x_j) \leq f(\ x\prime_j)\ then$
15. $end\ if$
16. $end\ for$

5. Sending the Scout to Search for Possible New Food Sources

The scout bee carries out a random search to replace the abandoned food sources, using equation (4). The abundant food source is one that cannot be improved upon after a certain number of cycles, as determined by the limit parameter. Algorithm (3) describes the process of the scout bee;

In algorithm (3), Scout is a vector of size (SN), which contain information related to the improvement in any of the food sources during search.

Algorithm 3: Scout Bee Phase

1. $for\ i = 1,2,..,SN\ do$
2. $if\ \ (scout(i) = limit)\ \ then$
3. $generate\ \ x_j\ \ using\ equation\ \ (4)$
4. $end\ if$
5. $end\ for$

6. Memorizing the best Food Source

This involves memorizing the fitness and position of the best food source, x^{best} found so far in FSM.

7. Stop Condition

Steps 3 to 6 are repeated until a stop criterion is met. This is originally determined by the MCN value.

III. Simulation and Results

Simulation is carried out using MATLAB 2019a.

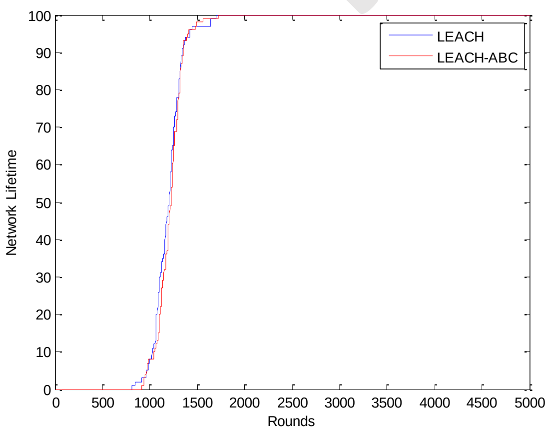

Figure 2: Network lifetime comparison between LEACH and ABC-LEACH for 100 nodes and 5000 rounds

The Figure 2 shows network lifetime comparison for LEACH and ABC-LEACH. Considering field dimensions in x and y directions to be 100 meters. The total numbers of nodes are assumed to be 100 with 10% probability to become a cluster head. Initial energy of the energy model is 0.5. The performance is evaluated for 5000 iterations and it is noticeable that the proposed ABC-LEACH approach outperforms the LEACH protocol.

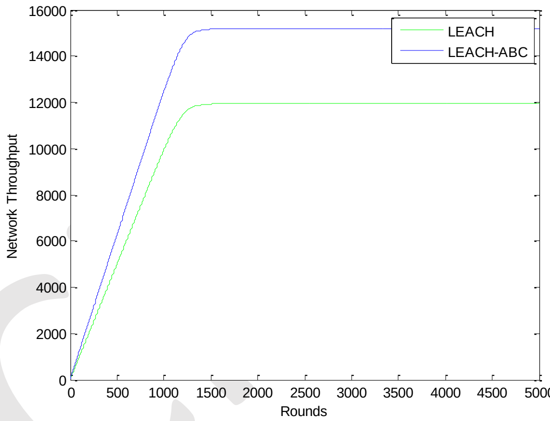

Figure 3: Throughput comparison between LEACH and ABC-LEACH for 100 nodes and 5000 rounds

The Figure 3 shows network throughput comparison for LEACH and ABC-LEACH. Considering field dimensions in x and y directions to be 100 meters. The total numbers of nodes are assumed to be 100 with 10% probability to become a cluster head. Initial energy of the energy model is 0.5. The performance is evaluated for 5000 iterations and it is noticeable that the proposed ABC-LEACH approach outperforms the LEACH protocol.

IV. Conclusion

Under the conclusion of this paper, several points were taken under consideration. For better understanding of our work that is evaluation of routing protocols for Wireless sensor network we have framed our work in two scenarios which consist of a simple WSN protocols, for now we have taken LEACH protocol in consideration and performed a comparative study by implementing various topologies.

This research work proposes an energy management framework in Wireless Sensor Networks using Artificial Bee Colony optimized LEACH algorithm. It was found that the ABC-LEACH outperforms the LEACH on the basis of network lifetime and throughput.

Reference

[1] N.R. Wankhade and D.N. Choudhari, “Advanced

IJDACR
International Journal Of Digital Application & Contemporary Research

International Journal of Digital Application & Contemporary Research
Website: www.ijdacr.com (Volume 8, Issue 11, June 2020)

Energy Efficient Routing Protocol for Clustered Wireless Sensor Network: Survey", *International Journal of Emerging Technologies in Computational and Applied Sciences (IJETCAS)*, Volume 9, No. 3, pp. 237-242, June-August 2014.

[2] You-Chiun Wang, Wen-Chih Peng and Yu-Chee Tseng, "Energy-Balanced Dispatch of Mobile Sensors in a Hybrid Wireless Sensor Network", *IEEE Transactions on Parallel and Distributed Systems*, Volume 21, No. 12, December 2010.

[3] Gerard Chalhoub and Michel Misson, "Cluster-tree Based Energy Efficient Protocol for Wireless Sensor Networks", *International Conference on Networking, Sensing and Control (ICNSC) IEEE*, pp. 664-669, April 2010.

[4] Rathna R. and Sivasubramanian A., "Improving Energy Efficiency in Wireless Sensor Networks Through Scheduling and Routing", *International Journal Of Advanced Smart Sensor Network Systems (IJASSN)*, Volume 2, No. 1, pp. 21- 27, January 2012.

[5] M.A. Matin and M.M. Islam, "Overview of Wireless Sensor Network", *InTech*, pp. 03-24, 2012.

[6] Harshwinder Singh and Navpreet Kaur, "Energy Efficiency Techniques for Wireless Sensor Networks: A Review", *International Journal of Innovative Research in Computer and Communication Engineering*, Volume 2, Issue 5, pp. 4138-4142, May 2014.

[7] Kamaldeep Kaur, Parneet Kaur and Er. Sharanjit Singh, "Wireless Sensor Network: Architecture, Design Issues and Applications", International *Journal of Scientific Engineering and Research (IJSER)*, Volume 2, Issue 11, pp. 06-10, November 2014.

[8] Balakrishnan, Baranidharan, and Santhi Balachandran. "FLECH: fuzzy logic based energy efficient clustering hierarchy for non-uniform wireless sensor networks." *Wireless Communications and Mobile Computing* 2017 (2017).

[9] Murtaza, Zain, Mohsin Ali Khan, Husnain Ahmed, Usman Ayub Sheikh, and Ghulam Shabbir. "Cost-based hierarchical energy efficient routing scheme for WSNs." In *Robotics and Artificial Intelligence (ICRAI), 2016 2nd International Conference on*, pp. 218-224. IEEE, 2016.

[10] Ahmad, Tauseef, Misbahul Haque, and Asad Mohammad Khan. "An energy-efficient cluster head selection using artificial bees colony optimization for wireless sensor networks." In *Advances in Nature-Inspired Computing and Applications*, pp. 189-203. Springer, Cham, 2019.