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A Hybrid Artificial Bee Colony Genetic Algorithm (ABCGA) Approach for Energy Efficiency in Wireless Sensor Network Communication

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Abstract: Non-rechargeable batteries with restrained energy capability are used to power the wireless sensor network nodes, but in hostile conditions, replacing a node battery is a difficult task. Thus, enhancing the energy efficiency resulting in increasing the lifetime of the network is a suitable decision. Recent work suggests that clustering is an efficient mechanism for reducing energy consumption, increasing network scalability, maintain load balancing, all of which contribute to maximizing total network life. Appropriate cluster head selection in a cluster is also crucial as it prominently affects the wireless sensor network life. Metaheuristic algorithms can be utilized effectively for this. This paper main contribution is to design a bee colony optimization technique named ABCGA dependent on an artificial bee method. In the proposed algorithm ABCGA, the artificial bee method is integrated with the features of the genetic algorithm for optimal cluster head selection. Also, data compression is done before data transmission, resulting in reduced energy consumption and increased network life. Simulation findings demonstrated that the proposed approach ABCGA outperforms the LEACH, PBC-CP, PSO, and HSA-PSO techniques in terms of the following factors- the number of active nodes, the number of nodes dead, Remaining Energy, and Throughput.

Index Terms **- WSN, Sensor nodes, Artificial Bee Colony (ABC), Clustering, Genetic Algorithm (GA), Energy Conservation, Lifetime, ABCGA.**

I. INTRODUCTION

Wireless Sensor Networks (WSNs) technology has managed to achieve popularity around the world lately. It comes forth as a result of network technology advancements and micromechanical and microelectronics systems expansion. It is a novel concept and a direct consequence of recent evolution in the field of communications. A wireless sensor network (Figure 1) consists of independent sensor nodes scattered throughout the region to monitor various targeted phenomena. A wireless sensor network typically consists of hundreds or even thousands of sensor nodes. The power and memory capacity of these sensor nodes is finite [1]. Sensor nodes collaborate to send data through the network to the base station (BS) or sink. The base station further provides connectivity to the wired world, where it routes data from the WSN to the server.

WSN two main component includes: Sensor Nodes and Base Station.

1. Sensor Nodes: A sensor is a module that senses changes in its surrounding environment and measures environmental conditions such as motion, temperature, vibration, humidity, sound, pressure, and pollutants. WSN has several sensors available such as proximity sensor, passive infrared sensor, humidity sensor, infrared sensor, photoelectric sensor, gas sensor, chemical sensors, etc, each with different applications. A sensor node contains a sensing unit, radio transceiver, processing unit, power control unit, and external memory. Figure 2 shows the block diagram of a sensor node. For power, the wireless sensor nodes rely on batteries. The sensor nodes in a WSN are resource-bound. They have confined storage space, computational speed, and transmission capacity.

2. Base Station: Central gateway is another name for the base station. The BS [2] has significantly higher energy, computing power, and communication capabilities than the other WSN components. BS is responsible for transmitting the data collected from the wireless sensor nodes to another network or server. The positioning of the base station in wireless sensor networks is a hot study subject because each wireless sensor nodes transmit their data to the BS for computation and decision making. The issues addressed over the BS placement in the network include reliability, energy efficiency, and sensor nodes coverage. The base station can be mobile or immobile in nature.

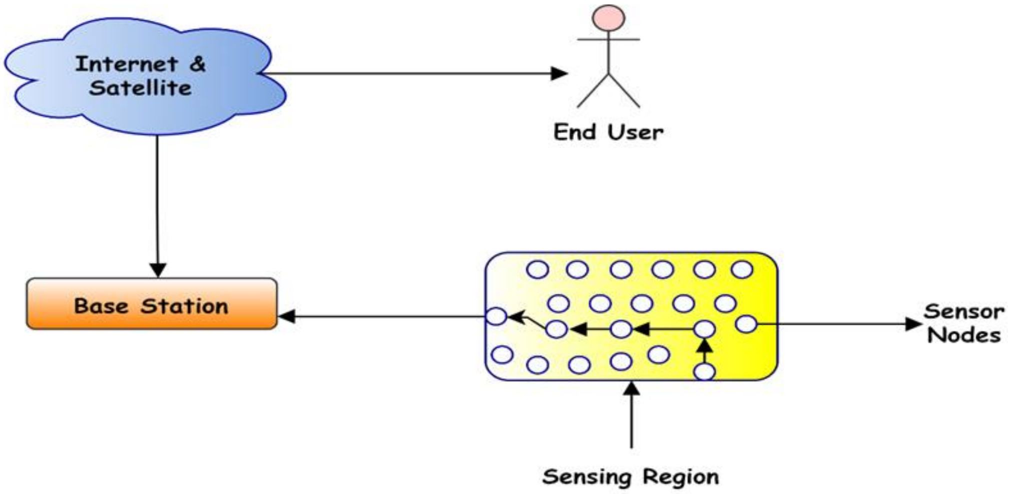


Figure 1 Wireless Sensor Network Model

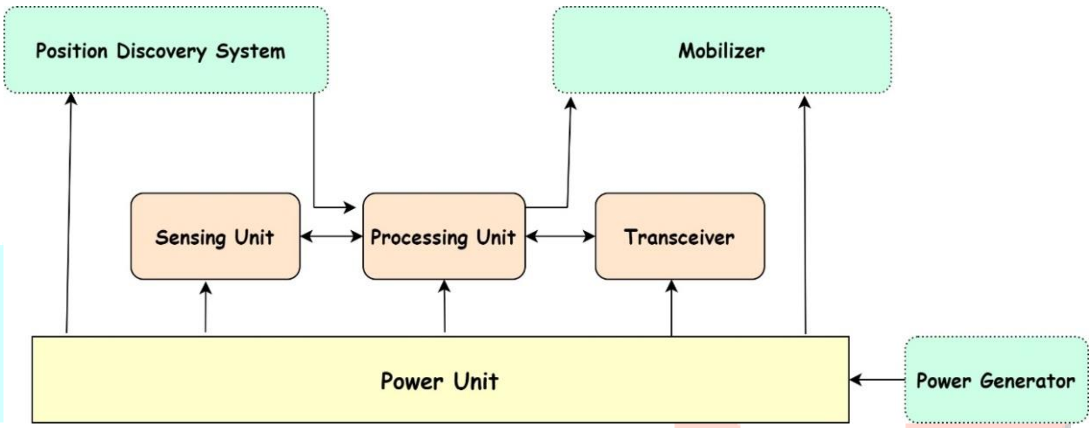


Figure 2 Sensor Node Block Diagram

Application of Wireless Sensor Networks

Wireless sensor networks popularity is growing over time because of their versatility in tackling challenges across a wide range of applications. WSNs are capable of impacting our lives in a variety of ways. WSNs have been employed effectively in numerous fields of application. Some applications are listed below and Figure 3 shows applications of WSNs.

1. Applications in Health Care: In health care [18], WSNs play an active role. Health applications of WSNs include remote monitoring of patients, the interface of assistance for people with disabilities, integrated patient monitoring, administration of drug medication in hospitals, diagnosis, keeping check of patients or doctors within a hospital.

2. Environmental Monitoring: The use of WSNs in environmental monitoring applications [4] has accelerated in recent years. These include agricultural monitoring, air pollution monitoring, habitat monitoring, climate monitoring, forest fires detection, radiation monitoring, greenhouse monitoring, landslide detection, seismic activity monitoring, indoor monitoring, earthquake detection, and a chemical or biological emergency.

3. Military Applications: The application of WSNs in military operations is of significant use. Sensor nodes are deployed in military operations to increase operational efficiency, reduce risk, reinforce sovereignty, and decrease causalities. The usage of WSNs in military applications covers enemy tracking or reconnaissance, security detection, battlefield surveillance, sniper detection system, landmine detection, and communication control.

4. Home Applications: As technology advances, it figured a way into our household appliances to ensure that they function without difficulty. In our household gadgets, we can see these sensors available. Such as in security system, light control, window and door control, vacuum cleaners, water monitoring system, ovens, and refrigerators. With the use of WSNs, the user can operate devices both locally and remotely. WSNs, in simple words, can be employed for home automation.

5. Application in Transportation: The use of WSNs in the transportation system includes a wide range of functions like parking assistance, autonomous vehicle, accident prevention, and traffic monitoring. WSNs collect real-time traffic data to update the modelling of the transportation system. Additionally, also notifies drivers of traffic congestion and parking difficulties.

6. Agriculture Domain: Precision agriculture employs WSNs to improve crop quantity and quality by monitoring various environmental factors like soil moisture, humidity, potential value of hydrogen (PH), water level monitoring, temperature, etc. In addition, WSNs contribute to the lowering of natural riches usage in agriculture. WSNs are also utilized for animal tracking to

safeguard crops from wild animals. An automatic irrigation system in farming that uses a wireless sensor network allows us to use water more appropriately and reduces water wastage.

7. Public/Industrial Application: Machine monitoring, inventory monitoring, structural monitoring, chemical monitoring, and factory monitoring are all possible applications of WSNs.

Figure 3 Wireless Sensor Network Applications

Clustering

One of the most crucial WSNs objectives includes minimizing energy consumption and extending the network's life. Clustering algorithms are one of the methods for achieving this objective. A wireless sensor networks node has limited resources. So, transferring data directly to the sink or base station can result in inefficiency in resource usage, interference, and energy waste. As a result, through clustering strategies, these problems are solved. As with clustering, the member nodes can send data to their respective cluster heads (CHs) rather than sending it directly to the sink.

Clustering [3] [19] process orders the nodes in a wireless sensor network into meaningful groups termed clusters. The arrangements of nodes into these clusters depend on several pre-determined specifications like improving resource utilization, network load balancing, supporting Quality of Service, etc. The two types of nodes in a group (cluster) include member nodes and CHs nodes. After sensing data, a cluster's member nodes either transfer it directly to the CH or use middlemen nodes to relay it to the CH. While the cluster head gathers data send from these member nodes and sends it to the base station. Selecting an appropriate cluster head for a cluster is a challenging task [14] as cluster head must have more energy than cluster member nodes. Additionally, it must be active at all times.

There are many Advantages of clustering such as: Clustering upholds WSN scalability, by stabilizing the overall topology of the network, clustering decreases the topology maintenance burden, organizing nodes in a cluster reduces the redundant message exchange amongst the nodes. The cluster head integrates the data and broadcasts it to the base station, decreasing the interchange of messages if each node interacts with the base station. The cluster head equally distributes the load between the cluster members thereby, enhancing WSN performance. Clustering is represented using Figure 4.

Cluster head selection method in a cluster

1. Nodes that are rich in resources are pre-assigned as cluster heads in some clustering techniques. Using this strategy for CH selection can be ineffective in numerous situations because most wireless sensor networks are resource-limited and homogeneous. In the case of a heterogeneous network, even if we find and choose a resource-rich node to serve as the cluster head, it won't last long for a considerable time as its energy will rapidly deplete serving as CH, resulting in node death.

2. Randomness is another way that several clustering approaches use to distribute cluster head duty amid nodes. LEACH is the most renowned clustering algorithm that uses randomness for cluster head selection. When cluster heads selection happens randomly, parameters like communication costs and remaining energy are not considered. Also, the clusters formed in this strategy remain unstable.

3. Conscious Cluster Head selection is the third way for selecting CHs. In this approach, the CH selection depends solely on network and node details. The parameters considered for selecting a node as Cluster Head include the number of neighboring nodes, locality, energy remaining, communication cost, distance to the BS etc.

The most reliable cluster head is the one that is closest to the base station, has the most neighbor nodes and maximum amount of remaining energy.

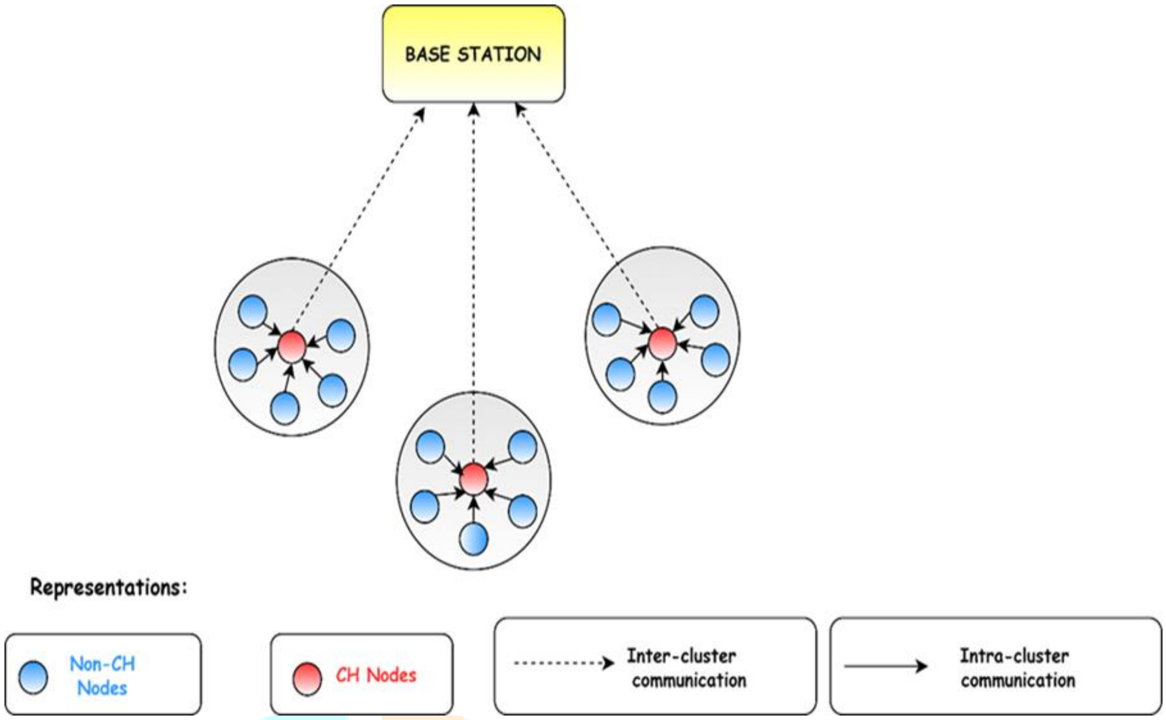


Figure 4 Clustering in Wireless Sensor Network

Modern communication systems require a wireless sensor network as a basic necessity. But, the WSNs will not be able to operate for an extended period due to the restricted battery life of the sensors used. Cluster-based routing techniques are used as a solution to address this problem. Also, many studies are carried out in the past and are still in operation to develop efficient algorithms for transmitting data in WSNs and prolonging WSNs life. Nature-inspired algorithms are one of these algorithms that are gaining much interest for the researchers who research the domain of clustering algorithms. So inspired by this, we have presented a modified variation of the Artificial Bee Colony (ABC) algorithm, which is one of the nature-inspired algorithms, in this paper. The Artificial Bee Colony Genetic Algorithm (ABCGA) is the name given to the unique algorithm developed. This newly designed algorithm has addressed most of the shortcomings of the existing BEE technique and also extended the network lifetime.

The following are the paper's key contributions:

1. To implement an equally distributed clustered network with consistent nodes deployment to handle issues like unbalanced node's clustering and excessive data requests.
2. To propose ABCGA, a modified Bee colony optimization algorithm by integrating the features of Genetic Algorithm (GA) for CH selection.
3. To implement a Huffman based data compression scheme to reduce nodes energy usage.
4. To perform an analysis of the proposed scheme over performance factors like energy consumption, network lifetime, data packets etc.

The remaining paper is arranged out as follows. Segment II discusses related work. In the related work GA along with the Genetic operators has also been explained. In segment III, the ABC model along with the ABC algorithm and the proposed work (ABCGA algorithm) is presented. Segment IV discusses the proposed algorithm ABCGA experimental setup and performance report and the conclusion and Future Work of the paper in Segment V.

II. RELATED WORK

Low-Energy Adaptive Clustering Hierarchy (LEACH) [15][16], a clustering-based protocol. In this the cluster head is selected depending upon probability. It has various shortcomings: 1. Arbitrary and varying size cluster creation: for example- In some clusters, the count of the node is more while others have fewer nodes. 2.Uneven distribution of CHs: - For example- Some CHs may be in the cluster's center, while others may be on the cluster's periphery. Due to this, the energy consumption is more. 3. Every node has some probability of becoming a cluster head. So, if a node with low energy becomes a CH, this node dies quickly, decreasing the network's life. 4. Load distribution among the CHs is not uniform. Many variants of LEACH are present that are continuously trying to increase its performance.

Ant Colony Optimization (ACO) is an optimization method that takes inspiration from the bio-semiotic communication between ants. Each Ant constructs a solution using a stochastic greedy method using a combination of a heuristic function and pheromone trail following. It is related to the class of algorithms known as Swarm optimization. In [17], the author mentioned that ACO algorithms are applied in WSNs for finding the best route for transmitting data in WSNs. The parameters used for finding the optimal path to the nodes include the remaining energy of nodes and node mobility.

Particle swarm optimization (PSO) [5] simulates the behavior of a flock of birds or a shoal of fish. In this scenario, each particle/bird has a velocity and position assigned to it. Particles adjust their velocity in order to shift their positioning to obtain food, escape predators, and determine optimal environmental parameters. Each particle optimizes the best position that it has discovered. Particle disseminates information about the best location they've explored. Particle velocity is adjusted using particle flight experience and group flight experience. In [6], the author proposed an energy efficiency CH selection algorithm that depends upon PSO. In this, the sensor nodes link with the CHs using the derived weight function. For the proposed PSO technique energy efficiency, numerous parameters taken into account were: sensor nodes residual energy, distance to the sink, the distance between the cluster members.

An artificial ants clustering algorithm (ANTCLUST) is a clustering method that employs the colonial closure standard considering objects like ants and clusters like nests. Based on the Artificial Ants Clustering Algorithm approach, the authors [7] presented a new clustering algorithm. This proposed new clustering algorithm firstly employs local communication between sensor nodes to create self-organizing and distributed energy-efficient clusters. Secondly, it also enables WSNs to gather data in a more energy-efficient manner.

The authors of this paper [8] introduced a combination of the Particle Swarm Optimization (PSO) and Harmony Search Algorithm (HSA) algorithms for choosing an energy-efficient cluster head. HSA, a community-based meta-heuristic optimization technique, was proposed by Geem et al. in 2001. To solve an optimization problem, the HSA mimics the syntax of a distinctive harmony in music. In this paper, the limitations of PSO are eradicated in HSA and the limitations of HSA are being covered by PSO. In simple words, this algorithm incorporates the best features of both HSA and PSO.

The authors of this paper [9] proposed a hybrid algorithm that is based on the Differential Evolution and Simulated Annealing (DESA) for making the clusters and selecting the CH in the WSN network. Generally, the incorrect selection of CH node, leads to earlier node deaths, as cluster heads are overcrowded with a large number of sensor nodes. The main contribution of this paper was to enhance the lifespan of the WSN network by reducing the node deaths.

In [10], the author introduced a fractional artificial bee colony (FABC) to increase the network's lifespan by choosing CHs appropriately. FABC is a hybrid of fractional calculus and the ABC algorithm. Its main contribution was to regulate the rate of convergence of ABC by creating a new neighbor solution using the derivates of fractional calculus. In this, using parameters like distance, energy, and delay, a novel fitness function is generated. Further, using this newly acquired fitness function, the evaluation of CH is done in this algorithm.

In [11], the author introduced a combination of ACO and ABC algorithms to develop a new innovative energy-efficient routing algorithm based on swarm intelligence. Artificial Bees Colony Ant Colony Optimization (ABCACO) was the name given to this new algorithm. This algorithm combines the ABC algorithm's ease of use and rapid convergence with the ACO technique of solving routing problems to achieve higher goodput and stability, resulting in increased network lifetime.

In [12], the authors suggested an energy efficient method that was based on Artificial Bee Colony Algorithm (ABC). The developed model was named as Proficient Bee Colony-Clustering Protocol (PBC-CP) that decrease the energy consumed by nodes and increased network lifespan. The optimum selection of the CHs plays a very crucial role in WSNs as they are responsible for collecting, processing and transmitting the data to the sink node. Therefore, the authors considered three important factors i.e., residual energy, node degree and distance between the BS and node for selecting the best CH in the network. Moreover, an energy efficient path is chosen for communication between CH and sink node which decrease energy consumption of nodes to a large extent. In paper [13], the author proposed a Genetic Algorithm based Energy-efficient Clustering Hierarchy (GAECH). In this, a suitable fitness function has been discovered to form balanced clusters enhancing both lifespan and network stability.

III. PROPOSED WORK

The existing traditional BEE approach was utilizing the random node deployment strategy to support the assumption of pre-thrown nodes in the sensing region. These irregular placements of nodes in the cluster put a negative impact on the efficiency of a wireless sensor network. For example, the load-related issues, large data packets while data gathering, sensing the whole network effectively etc., cannot be exploited easily. In addition to this, the traditional Bee Colony algorithm was focusing on network structure, clustering and CH selection only and other than as concluded from literature study is that there are very few studies those do focus in handling the sensed data. Reducing the unnecessary data communication or by reducing the size of data may also help in maintaining the consumption of energy.

The proposed protocol has two phases in it, one will be the Setup phase and the other is the communication phase.

1. Setup Phase

In the Setup phase the network structure, node deployment, and CH selection will be performed by the proposed algorithm. Further network initialization in the proposed algorithm ABCGA is done like this, the network area is separated into small sections with each section behaving as a cluster itself. Due to this sectioning, the entire sensing region will be covered in total. After that node will be equally distributed in each section to provide uniform deployment of nodes in the network, which was not present in the traditional ABC. Splitting can be done till the level, that the network remains stable. Further for an efficient and improved cluster head selection the proposed ABCGA algorithm is used. The ABC algorithm working in this proposed algorithm ABCGA will be same as the traditional ABC, with the modification in the scouting phase of the traditional ABC algorithm. Employer phase and onlooker bee phase remain the same. The modification will be seen in the scout bee phase, where GA comes in picture.

Artificial Bee Colony (ABC)

ABC is a metaheuristic algorithm given by karaboga in 2005. It is a Swarm Intelligence Algorithm as well. The ABC algorithm was motivated by the Honey bee's intelligent foraging habit and is widely used to optimize numeral problems. The ABC method is easy to apply and adaptable and, it has a wide range of applications.

Components of Honey Bee Swarms:

1. Food Sources: Bee colonies have access to numerous food sources in a wide range of areas and, they can even fly long distances to explore food sources. The solutions in optimization can be considered as food sources. Each solution has a fitness function associated with it. The fitness function can be considered as profitability. Food source and solution can be used interchangeably. The fitness function is used to calculate the fitness value. In simple words, the quantity of nectar of a food source shows the efficacy (fitness) of the linked solution.

2. There are 3 categories of Bees:

1. Employed Foragers (Worker Bees): - These Bees are linked to a source of food and exploiting it. The worker bees share the information with a precise probability to other bees. This information includes distance, profitability, and direction from the nest.

2. Unemployed Foragers: - There are two types of unemployed foragers:

• Onlooker Bees: They watch the waggle dance performed by the employed bee when these employed bees come back to the swarm and unload the nectar and choose accordingly to follow that particular bee and start searching for the food source.

• Scout Bees: They start searching around the nest spontaneously.

Genetic Algorithm (GA)

Genetic Algorithm is one of the efficient algorithms for optimization in the engineering domain. In a WSN, a GA is applied to determine the optimum number of CHs. To modify the chromosome/solution, this algorithm employs three GA operations:

1. Selection
2. Crossover
3. Mutation.

Chromosomes are the first viable solution to the problem. The steps specifying the working of the Genetic Algorithm are: 1. firstly, randomly generate the initial population- Chromosomes, also known as genotypes. 2. Estimate fitness function for every chromosome then. 3. The selection operator is now employed to choose the parents depending on their fitness. 4. Apply the crossover or mutation operator depending on the need. 5. Evaluate the resultant strings fitness function, if the resultant solution discovered is optimal, stop the algorithm, if not proceed.

Selection Operator: Two parents are chosen for mating, out of all the randomly generated populations, supposing that the offspring developed have higher fitness compared with their parents. The following are some of the most common techniques employed in the selection operator: 1. Roulette wheel selection, 2. Elitism selection, 3. Rank selection, 4. Steady-State Selection, 5. Tournament Selection, and 6. Boltzmann selection.

Crossover Operator: In genetic algorithms, one of the most prevalent operators is crossover. The process of crossover is crucial for creating new chromosomes by crossing two or more parental chromosomes. While the crossing of chromosomes, genetic information is shared between the two chosen parent chromosomes. Chromosomes are crossed so that they result in the development of new, more productive chromosomes. These offspring chromosomes are the parent chromosomes of the next generation. Below is an example showing crossover of chromosomes.

For example,
Parent 1: 110000|010000, Parent 2: 001000|000001
Offspring 1:110000|000001, Offspring 2: 001000|010000

Mutation operator: In mutation the offspring bits are changed from 0 to 1 and from 1 to 0.
For example, 10001000→→00010001

The New Proposed ABCGA Algorithm

1. Initialize the Random Population. The number of food sources equals to the number of worker bees which is also equivalent to the number of onlooker bees.

2. Evaluate the fitness function. The fitness function computation formula in ABCGA is mentioned below.

$$Fitness = w1 * ResidualEnergy * NodeDegree + w2 * \frac{1}{SinkDistance}$$

Here, sum of w1 and w2 is equal to one.

Set trial counters for all the food sources to zero. The trial counter is used to track the number of failures encountered by each solution. Every solution is associated with an individual trial counter.

3. A loop is run for the specific number of rounds and the below phases are repeated for different rounds.

4. Perform Employee Bee Phase of all food sources.

Employed Bee Phase:

1. The employee bee tries to identify better food source than the one they are associated with it.

2. They use a partner solution to generate the new solution.

$$X_{new}^{j} = x^{j} + \varphi(x^{j} - x_{p}^{j})$$

Here, j^{th} variable is selected randomly from all the available decision variables. In our proposed algorithm we have taken one decision variable. The value of range between [− 1, 1]. X_{new}^{j} refers to the new solution. x^{j} refers to the current solution. x_{p}^{j} refers to the partner solution selected randomly.

3. Bound the newly generated solution

$$1. X_{new}^{j} = lb(lowerbound) if X_{new}^{j} < lb,$$
$$2. X_{new}^{j} = ub(Upperbound) if X_{new}^{j} > ub.$$

4. Evaluate the fitness function (fit_{new}) .

5. A Greedy selection is employed to compare the solutions and, the new solution is accepted if it is better than the previous solution. Accept if is greater than the fit of the current solution and set trial counter to zero otherwise incrementing the trial counter.

Execute onlooker Bee Phase for the food sources that satisfy the condition described below

Onlooker Bee Phase: They choose a food source with a probability corresponding to the amount of nectar available. It also uses a partner solution for generating a new solution and a greedy selection is employed to compare the solutions. If the new solution is better compared to the previous solution, it is accepted. Onlooker Bee are different then the Employee Bee as for onlooker Bees, to exploit a food source, a condition needs to be satisfied. For each food source, the probability ($Prob_i$)is calculated using the quantity information of nectar associated with the food source.

$$Prob_i = \frac{fit_i}{\sum_{i=1}^{N} fit_i}$$

Here, fit_i is the fitness value of the solution/food source computed by the worker bee. This value is proportional to the amount of nectar present. N is the count of food sources available.

1. Roulette wheel selection is used on the onlooker bee phase to perform selection of a solution from all the current solutions on the basis of probability. Condition that needs to be satisfied: If $r < prob_i$, to generate a new solution. Here r is for random generated value, and $Prob_i$ is probability oriented along fitness.

2. They also use a partner solution to generate the new solution

$$X_{new}^{j} = x^{j} + \varphi(x^{j} - x_{p}^{j})$$

Here, j^{th} variable is selected randomly from all the available decision variables. In our proposed algorithm we have taken one decision variable. The value of range between [− 1, 1]. X_{new}^{j} refers to the new solution. x^{j} refers to the current solution. x_{p}^{j} refers to the partner solution selected randomly.

3. Bound the newly generated solution

$$1. X_{new}^{j} = lb(lowerbound) if X_{new}^{j} < lb,$$
$$2. X_{new}^{j} = ub(Upperbound) if X_{new}^{j} > ub.$$

4. Evaluate the fitness function (fit_{new})

5. A Greedy selection is employed to compare the solutions and, the new solution is accepted if it is better than the previous solution.

Accept X_{new} if fit_{new} is greater than the fit of the current solution and set trial counter to zero otherwise incrementing the trial counter.

6. Memorize the best food source. It is important to memorize the best solution before performing the scout phase as it can eliminate the best population due to the limit.

7. Execute Scout Bee Phase

Scout Bee phase: If trial of any food source/solution is greater than the limit, the solution can potentially enter the scout phase. Here limit is the user defined integer value or limit can be set as the multiplication of the number of food source and Dimension(D) of the problem. Solution with trial greater than limit are the candidates to be discarded. Only one solution with its trial greater than the limit is replaced with new random solution.

1. Identify the food source whose trial is greater than limit.

- if the trial>= limit, the solution is discarded and replaced with a solution generated at random using RandI function. Evaluate fitness function and assign fitness.

- else: The Genetic Algorithm cross-over is applied. The benefit that we get here is, even if, after executing the employed bee and onlooker bee phase, we do not get a good solution. We can get one more chance to get a better solution after applying the Genetic Algorithm in the ABC algorithm scout bee phase.

Finally, after applying all this procedure for CH selection, the node number to be selected as the cluster head is given as the output.

2. Communication Phase

The communication phase has also been improved in the ABCGA algorithm. As many algorithms have been introduced by the researchers that primarily focus on network structure, clustering, and CH selection but did not focus on handling sensed data. So here the proposed scheme also has the data handling scheme. For this Huffman Algorithm has been utilized. In Huffman Algorithm to perform Huffman encoding, Firstly Huffman dictionary is generated using symbols and their probabilities. Further, on the basis of this dictionary generated the data is encoded. The reason for using Huffman Algorithm is that it reduces the data packet size, due to which the individual's node's energy consumption will be reduced, and a successful transmission will be obtained without data loss. In simple words, by reducing the data packet size of each node the energy consumption has been improved directly. After Data Compression of each node. Transmission of this compressed data is done by each node in a cluster. All the member nodes of clusters transmit data to the cluster head and the cluster head aggregates this data and transfers it to the BS at the end. Figure 5 depicts the flowchart of the proposed ABCGA below.

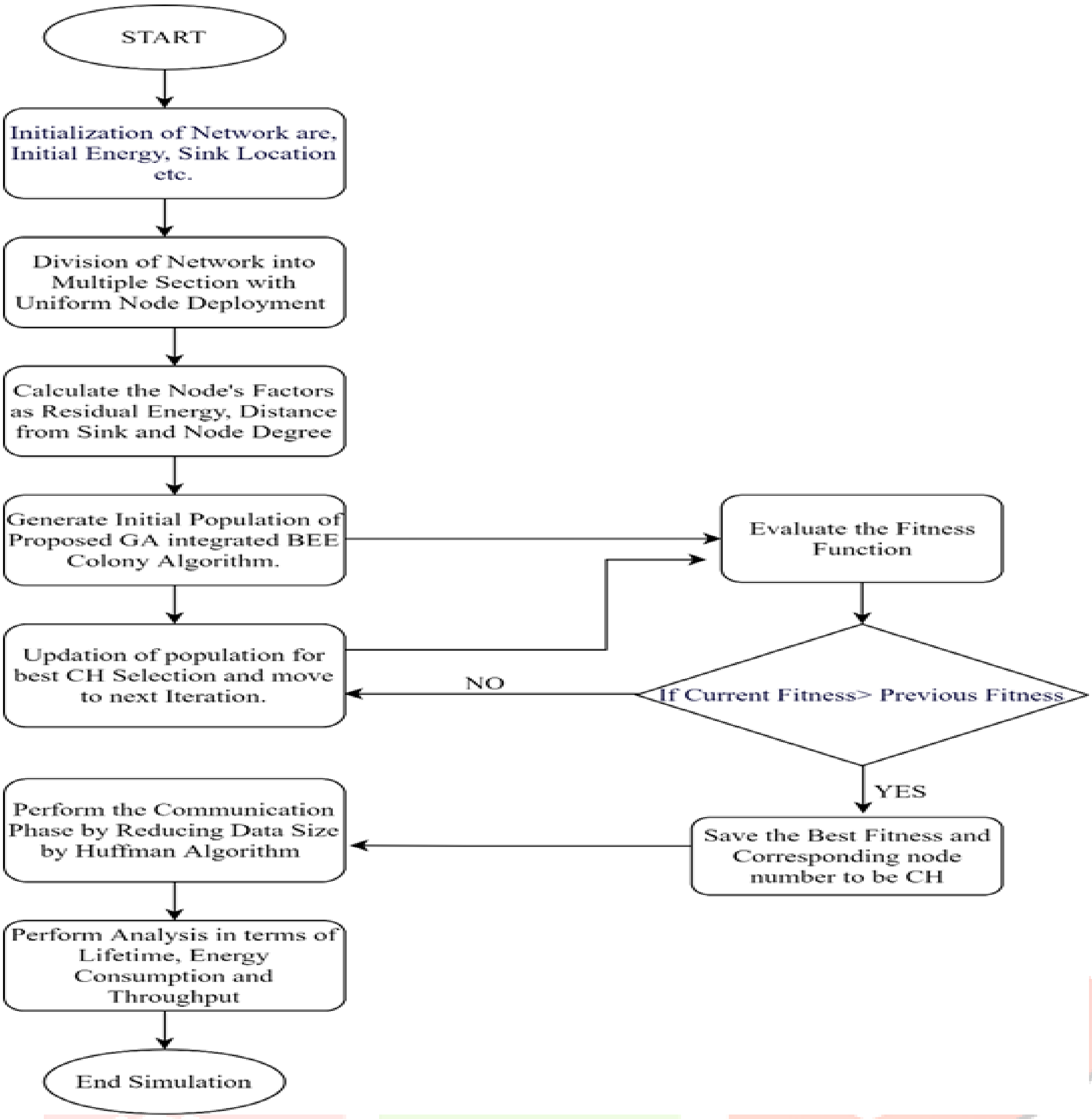


Figure 5 Working of Proposed ABC with GA

IV. EXPERIMENTAL SETUP

Hardware Requirements include Processor (Intel I, Intel II or higher), RAM (2 GB or more), Disk Storage (20 GB or more). Software Requirements include Operating System (Win-XP, Win-7 or any other higher version), MATLAB.

The assumptions are as follows: the initial energy for all sensor nodes in the network is kept fixed, and all node's information sharing and processing abilities are comparable. We likewise presume that the BS is not movable and not restrained concerning computing power, storage capability, and energy. Table 1. lists the simulation parameters needed for the comparison of different algorithms.

Table 1. Proposed Algorithm (ABCGA) Parameters for simulation [14]

Sensor field area ($X * Y$) (m)	(100 ∗ 200)
Base station position (x, y)	(50, 150)
Number of nodes (s)	100
Initial energy of a node (Eint) (J)	0.5
Data packet length (L) (bits)	4096
Energy/bit absorbed in the transceiver circuitry Ee (nJ/bit)	70
Energy/bit absorbed in the power amplifier (Efs and Etg) (pJ/bit/m2)	120 & 0.0013
Energy data aggregation (Eg) (nJ)	5
Number of rounds (Rmax)	3000

Simulation Results

For Several rounds of data transmission, the efficiency of our model is measured depending on the Number of Alive Nodes, Number of Dead Nodes, Network's Residual Energy, and Throughput.

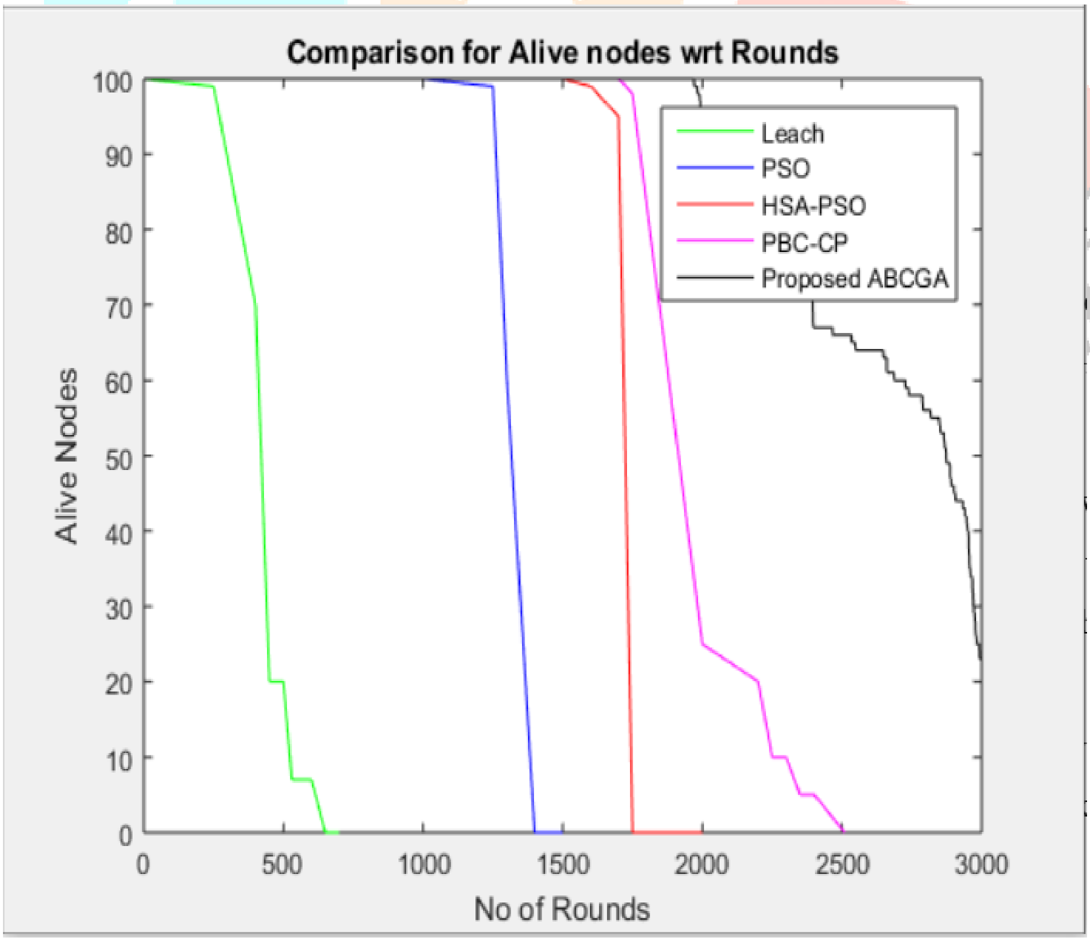
As displayed in Figure 6 below, we compared the outcomes of the proposed algorithm ABCGA with four standard protocols namely LEACH [15], PSO [5], PBC-CP [12], and HSA-PSO [8] based on the following parameters: Dead nodes, Throughput, Remaining energy, and Alive nodes in numerous rounds.

Figure 6(a) demonstrates that the Proposed algorithm ABCGA performance considering the number of nodes alive is improved than the other four standard communication protocols. After 255 rounds, 1300 rounds, 1700 rounds, and 1800 rounds correspondingly, alive nodes in LEACH, PSO, HSA-PSO, and PBC-CP begin to drop, whereas active nodes in the ABCGA algorithm start to drop after 2000 rounds.

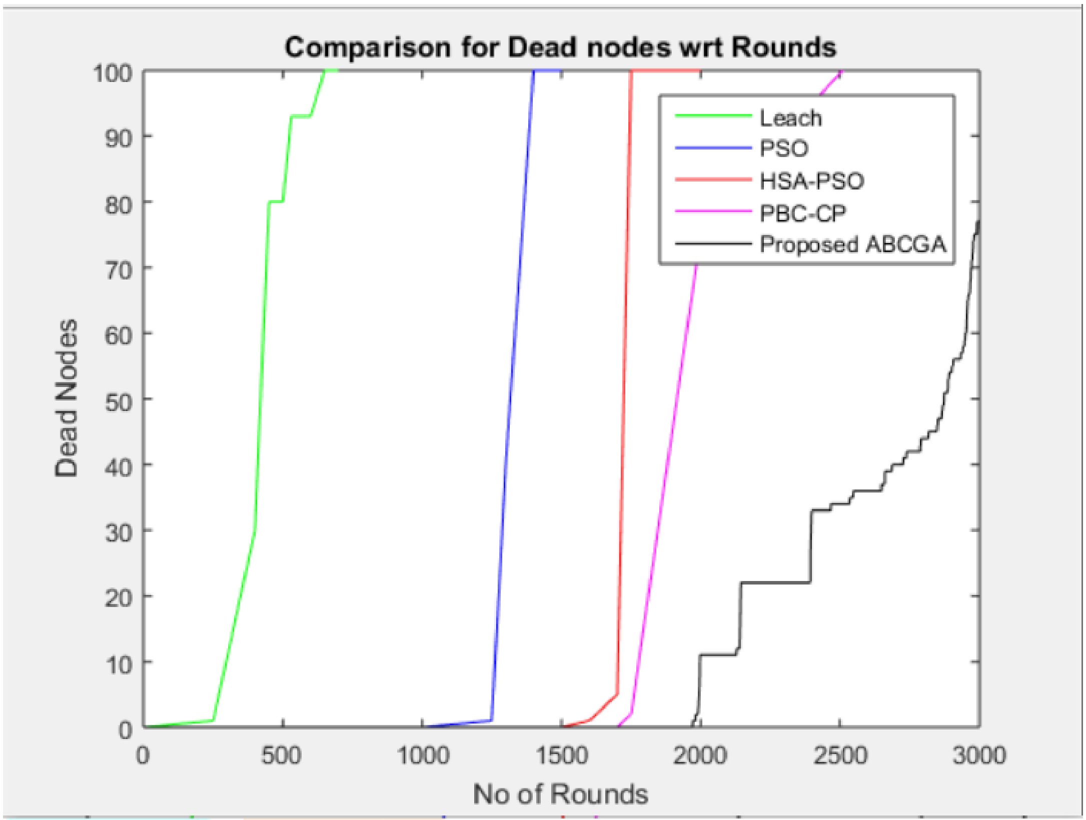
From figure 6(b), The first node died in LEACH, PSO, HSA-PSO, and PBC-CP around 206 rounds, 1238 rounds, 1632 rounds, and 1730 rounds, respectively. The results displays that the ABCGA algorithm surpasses the other algorithms because its first node is dead nearby 1900 rounds.

Figure 6(c) All of the algorithms considered in this paper have a maximum throughput of 0.41 Mbps. Throughput denotes the count of packets of data received at the sink in different rounds [10]. As the rounds proceed, the throughput value decreases. The number of rounds to which the maximum value of throughput is maintained in LEACH, PSO, HSA-PSO, and PBC-CP is 380 rounds, 1100 rounds, 1700 rounds, and higher than 2500 rounds. The ABCGA algorithm outperforms these four algorithms as for this, the maximum value of throughput is maintained for higher than 3000 rounds.

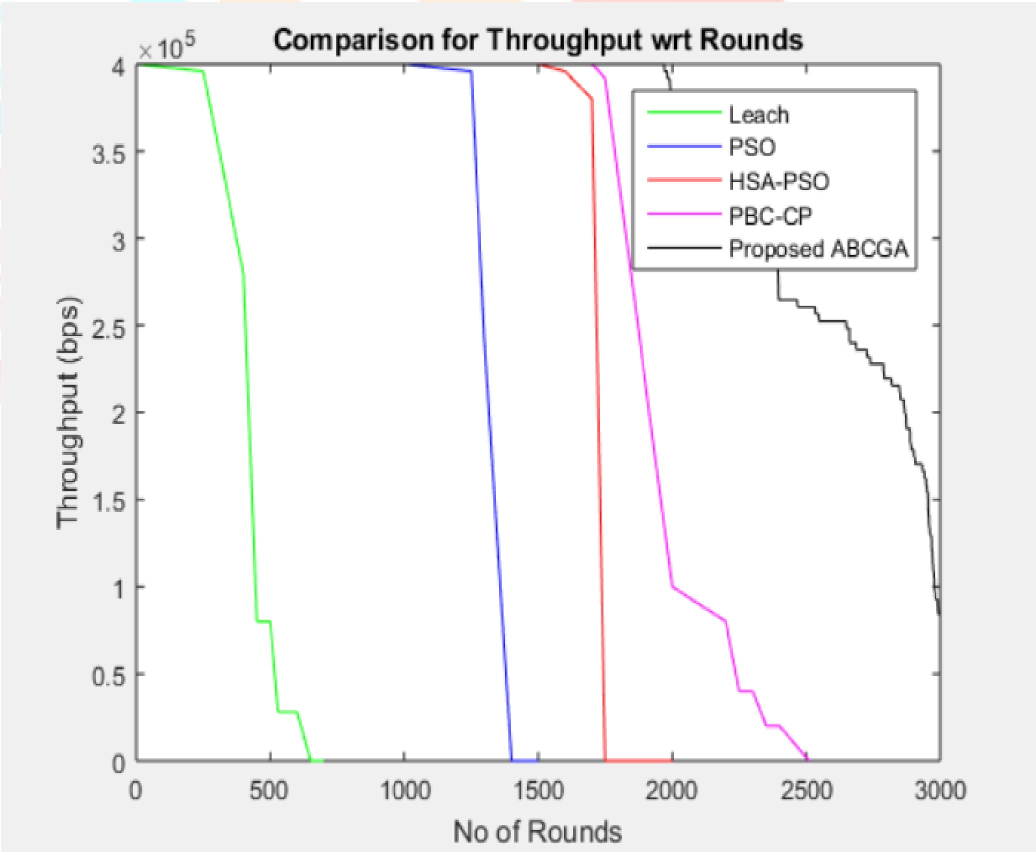
Figure 6(d) Close to 650 rounds, 1400 rounds, 1753 rounds, and 2500 rounds, the value of Residual Energy in LEACH, PSO, HSA-PSO, and PBC-CP begins to drop to zero. For the ABCGA algorithm, the residual energy begins to drop to zero after 3000 rounds.



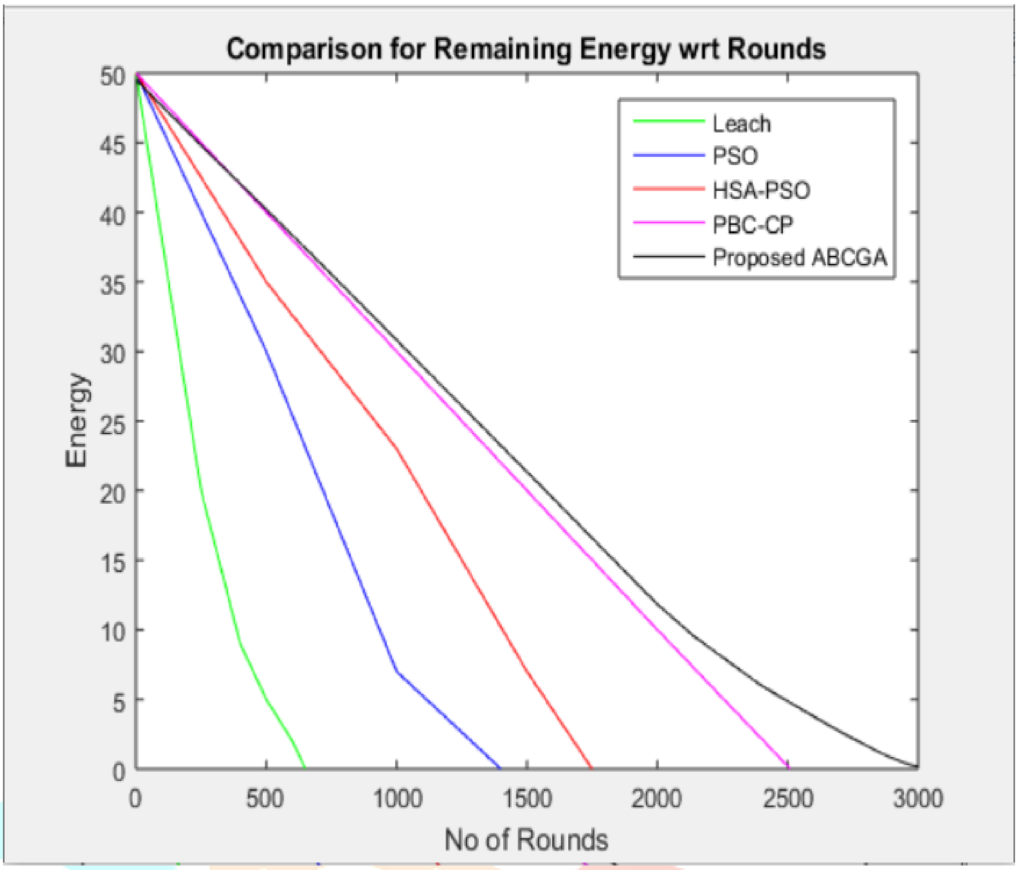
(a)


Comparison for Dead nodes wrt Rounds
Dead Nodes
No of Rounds
Leach
PSO
HSA-PSO
PBC-CP
Proposed ABCGA
0
10
20
30
40
50
60
70
80
90
100
0
500
1000
1500
2000
2500
3000

(b)


Comparison for Throughput wrt Rounds
$\times 10^5$
Throughput (bps)
No of Rounds
Leach
PSO
HSA-PSO
PBC-CP
Proposed ABCGA
0
0.5
1
1.5
2
2.5
3
3.5
4
0
500
1000
1500
2000
2500
3000

(c)



(d)

Figure.6. (Comparative Analysis of the LEACH, PSO, HSA-PSO, PBC-CP, and ABCGA Algorithms): (a) A comparison of the number of nodes alive concerning the number of rounds. (b) A comparison of the number of nodes deceased wrt rounds. (c) A comparison of throughput wrt rounds. (d) Residual energy comparison wrt rounds.

The Table 2. mentioned below gives a clear understanding of the simulation results showing the comparison results of the ABCGA algorithm with the standard remaining four algorithms.

Table 2: Summary of Simulation Results

Protocol	**First Node Dies After (No. of Rounds)**	**Alive Node Start Dropping After (No. of Rounds)**	**Remaining Energy Falls to Zero After (No. of Rounds)**	**Throughput Value maintained to maximum (No. of Rounds)**
LEACH	206	255	650	380
PSO	1238	1300	1400	1100
HSA-PSO	1632	1700	1753	1700
PBC-CP	1730	1800	2500	>2500
ABCGA	1900	2000	3000	>3000

V. CONCLUSION & FUTURE DIRECTION

The Proposed Algorithm ABCGA, in this paper is efficient in optimizing energy usage, conserving energy, and increasing the network life and is based on honey bee foraging concepts. ABC integrated with GA is used for CH selection and, the data is compressed before transmitting it to the BS. The appropriate CH selection and the data compression decrease the energy consumption and, the network life increases. The simulation outcomes show that the ABCGA algorithm outperforms LEACH, PSO, HSA-PSO, and PBC-CP regarding First Node Dies, Alive Nodes, Remaining Energy and also Throughput. As the throughput of the ABCGA algorithm is improved than the other algorithms, this implies that the amount of data transfer is increased by the proposed algorithm with significantly less energy consumption than the other algorithms resulting in effective wireless communication. During the execution of the ABCGA algorithm, the sink remains stationary. Future work may include multiple sinks and sink movement.

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