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Development and Analysis of Heuristic Clustering of Mobile Sensor Networks

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ABSTRACT: In this research, an optimal evolutionary method is described that may be used to solve actual challenges in Mobile Wireless Sensor Networks (MWSN), such as energy conservation. The bacterial conjugation operator is the only operator used throughout algorithm execution, making it considerably easier to use and apply the suggested method. The technique of the bacterial conjugation operator utilized in this technique differs from that of other evolutionary algorithms with the similar name, like the pseudo bacterial genetic method or the microbial genetic method. In this research, our goal is to extend the optimization problems for mobile wireless sensor networks. First, using Genetic Algorithm to optimize orthopedic optimization to sensor nodes to orthogonal optimization. Divide the installment and reduce the communication distance between the network nodes. One of the challenges for this algorithm is that the number of clusters is not personalized. This is the challenge of greater flexibility which allows sensor nodes to be placed in different environments. Another assumption is that the nodes are sensor nodes, as with previous algorithms, they are not considered uniform. So there is a limitation of non-uniformity in MWSNs. This allows this type of wireless sensor network to be used in different environments.

KEYWORDS: Mobile Wireless Sensor network; Heuristic Clustering Algorithm; Power Consumption; network lifespan

I. INTRODUCTION

The MWSNs have arisen, shifting the attention away from traditional stationary WSNs and toward networks with mobile sensor nodes competent of sensing a wide range of activities. They can also modify their location in a sensing area on a regular basis. Time-driven, event-driven, on-demand, and monitoring apps are all examples of MWSN applications. The essential aspects in designing an energy efficient MWSN for a certain application include mobile sensor node design, residual energy utilization, movement, topologies, adaptability, localisation, data gathering routing, Quality of Service (QoS), and so on.

The MWSN is an assortment of suspected sensor nodes such that they have the aptitude of moving and changing their position to interact with physical objects. Like fixed sensor nodes, movable sensor nodes have the capability to identify surrounding objects, calculate and communicate. The main difference is that the moving sensor nodes have the capability to change their position in the network. They can change their position and collect data. Information brought to you. By one sensor node can be transferred to other mobile sensor nodes. Another difference is the distribution of data. In fixed wireless sensor nodes, the data is pre-determined and fixed or distributed by CSS, while in mobile wireless sensor networks, routing is dynamic.

Error tolerance, wireless linking, scheduling, protection, condition monitoring, wireless communication, automation, and protection are just a few of the features available, hardware charge, network architecture, implementation, memory and battery dimensions, information processing, topology changes, sensor node/sink movement, exposure, power depletion, protocol scheme, extensibility, positioning, data and node based, network differences, hardware failures, QoS, data coalition and repetition, auto configured, inter-layer system, equitable traffic are some of the significant architecture issues for MWSNs [1-3]. Sensor network typically include one or many sensors to measure the heat, luminosity, moisture, moisture, compression, glow, closeness, and so on. It also has a microprocessor, exterior memory, radio transmission, (ADC) analogue to digital converter, antenna, and battery. Because of their compact size, the nodes have inadequate integrated stowage, battery capacity, computation, and radio capacity [4]. The topology of a mobile sensor node is essentially identical to that of a conventional sensor node. Conversely, for mobile sensor nodes, additional components like localization-location discoverers, mobilizers, and energy generators are considered. The

sensor node's position is determined by the location or site finder unit, and the sensor node's mobility is provided by the mobilizer. The power generator device is capable for producing power to meet the sensor node's additional power needs using any specialized approaches like solar cells.

II. NETWORK TOPOLOGY

In MWSNs, the network topology is critical for transferring data from mobile sensor nodes to the sink/base/central station. The internet is then used to join the sink and the distant user/server. huge MWSN' performance is solely dependent on the data gathering or topology organization strategy. As a result, the topology ensures a stable network with improved QoS in regards of motion traffic, and complete connectivity. Furthermore, in MWSNs, topologies specify the sensor node group's size, handle the introduction of fresh members to the group, and cope with the removal of members who quit the cluster. Consideration of different factors in network topology can result in effective data collecting with minimal energy consumption and the formation of improved MWSN. Depending on the characteristics of the MWSNs, several network topologies are used to guarantee the finest data gathering and network enactment. Depending on the network's characteristics, several network topologies are employed to optimize data collecting.

III. RELATED WORK

In contemporary era, the genetic algorithm (GA) has been widely used in many successful optimization problems. Biological operators, such as combinations and mutations in many algorithms Evolutionary have been used. Much of the research has consistently focused on the development of operators. Other algorithms adjust their focus to achieve consistency by avoiding clutter. Though, the evolutionary description of the above procedures had certain challenges. Another major problem is that many of these algorithms have many input parameters. Their demolition and commissioning requires specialization, which requires a distinct investigation for every trainer. Even For a surface algorithm genetic procedure with an input parameter level: population size, composition rate and mutation rate can be Pedestrians found various equations, such as the rectangular sales rectangle. These algorithms have multiple input operators can be implemented in different ways. In addition, finding optimal inputs it takes time for each musk and tedious processes.

In the article [5], an optimal evolutionary algorithm presents the orthodontics called HPGA (genetic algorithm with efficiency Very high using the bacterial compound operator (HPGA algorithm) from another genetic mechanism called compound Bacteria are used to transfer genes directly between cells. Bacterial composition algorithm of information transfer procedure. It models genetics between bacterial cells that are directly cell-to-cell. This operator is categorized as one of the procedures of genetic surface transfer. This operator increase speed of communication in network.

Clustering supports network extensibility and reducing power depletion (using data combination). There are countless other benefits [6], in proportion to the other different goals: Concentrate and localize the rectangular planar surface and, consequently, the size of the rectilinear table, It can maintain communication bandwidth as it extends the domain of intergroup interactions to clusters, Restricts and avoids the severance of exchange messages among sensors. Clustering can keep the sensor network architecture stable while lowering overhead and overall maintenance expenses. Reduce the topology, meaning that the sensors are maintained only when connected to their headers. They are and are not affected when there are changes in the levels between the heads. Network enactment and the battery life of the nodes are increased and thus increase the network lifespan

IV. METHODOLOGY

The bacterial synthesis algorithm splits the underlying layers of the conventional genetic algorithm from the surface transfer operator Genetics that uses a combination of bacteria in nature inspired. In this method, it is proven that the genetic information of the donor chromosome is useful for the recipient chromosome; Therefore, a chromosome with a high degree of suitability will serve as a donor chromosome for the population. This way it is also an evolutionary technique that decreases the intricacy of implementing and using computing resources during implementation. The most significant benefit of using the bacterial composition algorithm in comparison with the implemented algorithms is high performance of this algorithm without the need to adjust the initial parameters that the above algorithm for applications. It works immediately because it does not waste time to find the optimal parameters. The implementation method prevents premature convergence and will trigger accurate results.

In the orthodontic technique, the orthogonal nature of the orthogonal algorithm is typical of the orthodontic elimination and synthesis algorithm. Bacteria are the only masters. It should also be emphasized that this operator does not need another input parameter and it can be used for a variety of purposes; therefore, the initial population parameter value is the only input of this algorithm. Despite the different branches of the genetic algorithm, this method is faster

and has an input parameter. Procedures for this algorithm are less expensive and investigational outcomes display that the procedure combines the efficiency and high accuracy of PSO and SGA methods. In this dissertation, the bacterial composition algorithm for the first time for clustering movable sensor nodes was used and good results were obtained. Before referring to the results obtained from modeling this algorithm, we experiment of its operation and how this algorithm is applied to mobile wireless sensor nodes to discovery the value of optimally for clusters.

A. CLUSTERING IN MWSN:

The life time of sensor nodes in the MWSN determines the life span of the network and time. Network life is also significant parameters of service quality in sensor networks in sense applications. The lifespan of nodes is straight connected to the power depletion by them [7]. In sensor networks, we want to set up a good volume of sensors to reach a target for remote monitoring. All information composed by the sensors must be conveyed to a data collection centre. Longer intervals use more energy to send information. Each sensor sends information to the centre. Direct transmission networks are very simple and straightforward to design, but due to the high sensitivity communication, the sensors ingest a lot of power from the centre in contrast to the strategies that multi-hop communicate [8]. Owing to the high compactness of sensor nodes in surface units and, as a result, their proximity to each other, multi-step connections are more useful and cost-effective in such networks. They are more efficient than single-step connections, but due to the limited energy of each of the sensors and depletion of more energy in communication with other sensors. The use of multi-step connections is also costly. Due to the high power depletion in sensors the life of the sensor network is further reduced.

Employing clusters for each year of information to a base central station by requiring only a few nodes for communication from long distance to central station increases the benefits of short distance for most nodes. Clustering is such that we link the network to a number of dependent clusters that each Clustering is such that we link the network to a number of dependent clusters that each The installment has a line-by-line node that collects all the information from its line-by-line nodes. This Step by step to the main center using fewer steps and only using threaded nodes [9,10]. Optimization can significantly decrease the communication costs of most nodes; as they only want to get the information to the adjacent source, instead of sending it directly to the main center and shows how tempered reduces communication header in multi-step and single-step communication.

To understand the number of clusters Attempts to determine the optimal number of clusters in scenarios different has been done. In [11], a distributed algorithm in wireless sensor networks is proposed where each sensor with a probability chooses itself as a clue and informs its generalization. This algorithm allows the creation of one-step clusters. Each single step is analyzed and an analytical model is obtained to obtain the optimal number of headers. It provide a function of several factors like sensory field size turbulence, number of nodes, and

B. CLUSTERING USING EVOLUTIONARY ALGORITHMS:

Recently, clustering methods based on evolutionary algorithms have been extensively employed by researchers. These methods find the best dissemination of sensor nodes in the lattice region and present the energy-optimal model by finding the minimum amount of clusters in the network. Various optimization methods have been employed in this field stimulus: GA, ant and bee colony algorithm, PSO algorithm and so on. Each of these approaches use distinctive factors in their fitness function to achieve their goals. NP-hard quadrants and distinctive procedures have distinct efficiency in quadratic process. These methods are usually centralized and run at a central station because of the general information required and this information is available at the central station of the network.

C. BACTERIAL COMPOSITION ALGORITHM:

The bacterial compound operator is divided into two parts:Surface transfer of genes and competition. The method of superficial transfer of genes to father chromosomes is applied. Chromosome with the best chromosome fit The donor and the chromosome with the worst fit are the recipient chromosomes. The values of the best and worst fit in are known during the execution of the algorithm. After the gene transfer phase, a receptor chromosome and a new chromosome are created. They enter the competition stage from the first stage. The generated chromosome is the output of the bacterial composition algorithm. The input arguments of the bacterial composition algorithm are:Donor chromosome,

Receiver chromosome, the best fit and worst fit. The process of the algorithm combines the bacterium and the pressure shows application on two chromosomes.

D. SURFACE TRANSFER OF GENES:

In the first phase of the BC algorithm, the sequencing of genes from the chromosome does not donate to the chromosome. The receiver is placed in the same place. The beginning of the relevant gene string is randomly selected. The operation of this algorithm is separated into two key parts: surface transfer of genes and competition. The bacterial composition algorithm works by continuously selecting the sequences of genes from the donor chromosome. This practice has two input parameters: String length to be cloned (L) and preliminary point of the gene strand to be cloned (P). The length of the line that should be copied from the difference in the amount of parental fitness, divided by the difference between the best and the worst fit is achieved through the implementation of the algorithm. The value of L is obtained as per equation 1:

$$L = \frac{|Fitness(CH_{Donor}) - Fitness(CH_{Recipient})|}{|Fitness_{Best} - Fitness_{Worst}|} \times \text{Length of Chromosome} \quad (1)$$

To get the starting point of a gene strand, a randomly distributed value between zero and chromosome length is used. The value of P is obtained. As follows:

$$P = \text{Uniform Random}(0, \text{Length of Chromosome}) \quad (2)$$

After these two parameters are specified, the gene strand of the donor chromosome is stretched from point P and length L on the chromosome. The receiver is replaced in the same position. If during the transfer of genes, copying all genes ends. The operator goes to the end of the receptor chromosome on the barrier, continuing to copy genes from the beginning of the chromosome. It should be this point also considered that because the starting point of the gene copying operation is randomly selected, the chromosome Created in subsequent performances will also be different.

E. Competition:

In the 2nd stage of the bacterial synthesis operator, the chromosome removed from the gene transfer step enters the step. Competition with the recipient chromosome: the chromosome mutation operator acts with the worst fit to the probability of winning Increase it. The suitability values of mutated and non-mutated chromosomes are related with each other and the winning chromosome substitutes the recipient chromosome in the populace. In the mutation operator, the amount of genes to be mutated is known as Pgm, and this value for each chromosome it will be counted. The amount of Pgm depends on the number of analogous genes between two chromosomes. For each gene, at digit between zero and A stroke generation and if this number is less than the Pgm value, a jump is applied. The higher the chromosomes, the greater the number of mutations for the chromosome, the worse fit. Similarity criteria between chromosomes of the formula are the number of chromosomes of the genes in single-stranded locations of two chromosomes of half-length length. A chromosome is obtained that is a value between zero and one. The value of Pgm can be determined as follows.

$$\text{Similarity} = \frac{\text{Number of Similar genes between two chromosomes}}{\text{Length of Chromosome}}, p_{gm} = \text{similarity}$$

This makes it very effective by mutating the genes on the recipient chromosome. This possibility also exists. If the amount of L is too small for the length of the chromosome, the useful genes have a chance to be transferred to the chromosome. Consequently, the operator is designed to have as much chromosome fit as possible. The closer the recipient is to the suitability of the donor chromosome, the more mutations will be made.

F. STEPS OF THE BACTERIAL COMPOSITION ALGORITHM:

The stages of HPGA procedure are given and the steps of this algorithm are executed in order as shown in figure 1. The procedure begins by creating a primary population of chromosomes. For this objective, chromosomes form a random number of populations is created that make up our original population.

- The only operator in the predisposing algorithm is the bacterial composition and the chromosome donor chromosome with the best Fitness is out of the crowd.
- Calculation L requires the worst and best values, which are considered as the worst fit and the best fit Called. The best fit comes from the best chromosomes. The worst chromosomes must be in during the execution of Shatood storage algorithm. At this point, the best chromosomes and the worst chromosomes are formed. They are stowed individually from the population.
- In the stringed algorithm, a string ends when the BC operator apply on all chromosomes. Consequently, the succeeding stages apply to each hromosome: The first population chromosome is selected. The BC operator acts on the best chromosome as a donor and on the recipient chromosome.
- The fit of the chromosome created in the BC operator is compared with the best chromosome. It was better to be selected as the best chromosome. It is crucial that the chromosome created from the BC operator always has a better fit or equivalent to the members of the previous population. This operator does not need to have the right fit of the previous chromosomes. The point of the proverb is estimated as that the loser chromosome is evaluated by the BC operator to replace the worst chromosome. The reason for doing this is that this chromosome has never been placed in the population and if the worst fit with this chromosome is updated, the fit of the chromosome among the population will be close to the best value. So, the value of the parameter L is approximately equal Will be zero, which will reduce the efficiency of the algorithm.
- Operation on the chromosome: Select the full line and the algorithm to step 2 to select the next chromosome.
- Like the genetic algorithm, the condition for completing the algorithm used can be the number of nesses called the maximum ness is known.

V. CHARACTERIZATION OF MOBILE WIRELESS SENSOR NODES USING A BACTERIA COMBINATION ALGORITHM

Optimization of mobile sensor nodes has been performed to increase flexibility and increase network lifetime. The frame is economical and has been widely discussed by researchers in recent years. Each cluster has a leader who is often called a redhead. Saturation in mobile WSNs has been measured. The title of the problem is considered to be with high time complexity. Exploratory algorithms have a good result in these types of networks. Finding the optimal number of surface lines among moving sensors will be a matter of great difficulty. Suppose there are 433 sensor nodes to find ways to do this problem we need a different combination to find the desired solutions. As mentioned above, the algorithm. The combination of bacteria successfully responds well to the orthostatic planet and to the orthostatic genetic algorithm, such as [12], scheduling tasks for multiple processors and find the optimal number of eclipses and minimize power depletion and increase network life in the direction of improved network stability has been used. The implemented protocol consists of several different phases. It has a starting stage 2, which is the central station of the eclipses using the bacterial composition algorithm. Finds and in the next phase, i.e the steady state, ordinary sensor nodes become members of these rows. After mating the clusters, the collected data frames are transferred from the sensor nodes to the clusters and clustered. By processing this data, they send it to the central station.

A. START PHASE:

In the initial phase, the optimal number of clusters are searched and tested. In the first round, the central station sent short messages to wake up and collect the identification number; the position and energy level of all sensor nodes in the target distant. The sensors with the central station and the surface of the maps are collected and by implementing the bacterial algorithm, an optimal number of marked with Blocked Block - Selects sensor nodes as red. The central station also determines the members of each branch and forms the clusters. None of the nodes here, propel data directly to the central station. When the headlines were selected and the members of each cluster detected must be attached to this header and a message to all sensors containing the header that should be Join to send. According to the short message arriving from the central station, every line has a schedule based on the protocol Creates TDMA and specifies specific time intervals for each cluster member using these intervals. Sometimes it informs the nodes. TDMA Scheduling Reduces the possibility of preventing malformations. The energy is stored between the data messages and the possibility of turning off the sensors when the data for target is not provided. To prevent cross-linear interactions, also use the CSMA protocol with a single code uses unique and complete details of this code to enclose your data in this

way encode and cancel. The exact form of how to optimize sensor nodes using the bacterial composition algorithm below is explained in next paragraph.

B. STEADY STATE STAGE:

Here, the awake sensor nodes awake to collect data. Sensitize the data to it based on the TDMA timing and sends to cluster head. The link line node should hold its receiver in order to obtain data from other nodes. When the data is received, the threaded node processes the signal and converts it to a unified signal. This integrated signal is eventually transmit to the central station. After a definite time, it has already been determined that the network has reentered the startup mode and new headers are determined according to Bacterial composition.

C. DEFINE AND REVIEW THE PROBLEM:

To reduce energy consumption, choosing the right set of nodes is very important as shown in the algorithm

$$S = S_1, S_2, \dots, S_{N_S} \quad (3)$$

Create a set of sensors in the central station, select sensors that have an energy equal to or greater than the average energy of the sensors. The relationship between the sensors is shown as:

$$\forall i = \{1, 2, \dots, N_{live}\}: S_i \in S, \text{ if } E_{RS_i} \geq E_{AVG} \quad (4)$$

Where, S and N_{live} is the number of live sensor nodes in the state, E_{RS_i} is the remaining energy of the i^{th} sensor and E_{AVG} is the average enduring power of all living sensor nodes available. The Chromosome uses a bit stream with length N_S which counts the number of sensor nodes in the set S . Each bit or gene on a chromosome represents a sensor in the S set. When the corresponding gene is "1", best means that the corresponding sensor will be selected as the line line; Otherwise, it is shown that - Normal sensor face will be selected. Early population of chromosomes are used to create random set S with probability P and length N_S .

D. EVALUATE THE OBJECTIVE FUNCTION:

Our objective is to decrease the distance between the sensor nodes and their neighboring nodes and to reduce the distance between the neighboring nodes and the central station. In addition, the number of headers is also generally effective in the objective function. Decreased energy dissipation and high surface area increase the energy dissipation of nodes, because the cluster head does a lot of work on ordinary nodes and therefore consumes more energy; Therefore, Bacterial composition algorithm to discover the optimum value of the headers and increase the value of the objective function shown as follows:

$$fitness = w * (D - distance_i) + (1 - w) * (N - H_i) \quad (5)$$

The objective function used depends on two Distance factors, which are the sum of all nodes. It is normal with their cluster heads and the distance of these heads to the central station. H_i is the number of heads in the network. The bacterial composition procedure should have the least amount of headers and $Distance_i$. The above objective function is the direct distance of all nodes to the central station. N Number of sensor nodes and a default weight of $0 \leq w \leq 1$ which is used to further evaluate the algorithm for example. This means that the number of clusters is important to us, while $w = 1$ is a communication factor for us. Genetic algorithm starts with one set of random systems. After finding the perfect fit chromosomes can determine the number of nodes in a cluster. The objective function in [13], has been used for long distance communication with nodes is a very effective and efficient method that is able to find solutions in networks with the topology is uniform and non-uniform. The results show that the number of headers is equal to 43% of sensor nodes. Also in this technique, a 13% decrease in the communication distance between the sensors compared to the shipping method is obtained directly. The objective function used in this dissertation is extracted from the article [13]. Due to low computation and high improvement, it is very efficient in optimizing the problem.

E. Condition for completion of the algorithm:

At the beginning of the variable procedure, we specify the number of instances that the algorithm must execute. If the number of generated cluster heads exceeds this initial value, the algorithm terminates.

VI. SIMULATION RESULTS

After several simulations, the outcomes demonstrates that the recommended process is very competent because reduces communication distance and power depletion. For a different number of nodes from the following parameters in the table 1, shown for network and sensor nodes. Nodes are disseminated in 433 meter square area. The distribution of nodes is completely linear. Nodes \times Nodes in an environment with dimensions 433. The sensor is movable and the energy stored in the nodes at the beginning of the algorithm can be completely be the same. Also, the physical structure of the nodes is quite similar. Genetic algorithm parameters and bacterial composition are illustrated in Table 2. In the mutation rate calculation formula that SimGenes, the number of identical genes between two chromosomes and length is Ch_length. The chromosome is stable. The MATLAB achieve new protocol outputs. Long network life is the best result. Improved energy consumption has been achieved throughout the year. After the clustering phase, it also indicates a favorable situation at this stage of the network.

Table 1: Number and specifications of nodes

Parameters	Values
Network size	433 m ²
Number of sensor nodes	13
The sensory radius of the node	1 Meter
Node communication radius	3 meters

Table2: Genetic Algorithm Parameters and Bacterial Composition

Parameter	Bacterial composition algorithm	Genetic algorithm
Population size	13	13
Crossover rate		3.1
Crossover type		Single point
Mutation rate	SimGenes / (Ch_Length*10)	3.2
Generation size	433	433

We have a MWSN in areas with dimensions of 433X 33 meters with a uniform dissemination of 50 nodes (figure 2). We have some ordinary nodes and some nodes with extra power (43 J). Energy at the plane of the sensor nodes is equal $E_0 = 31$. They are ordinary sensors. This combination of energy is due to the use of heterogeneous sensors and has an effect on behavior.

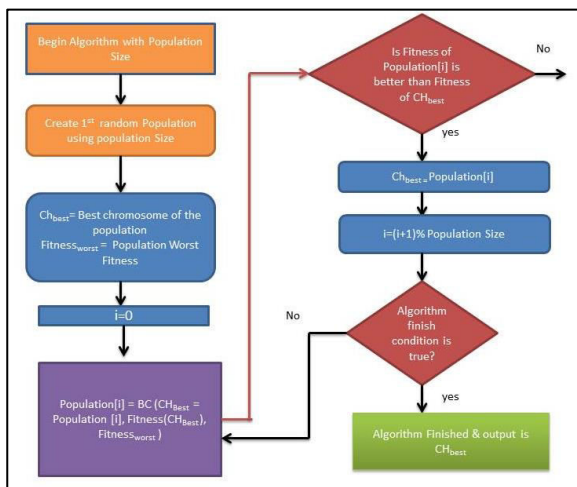


Fig.1.Execution of bacterial composition algorithm

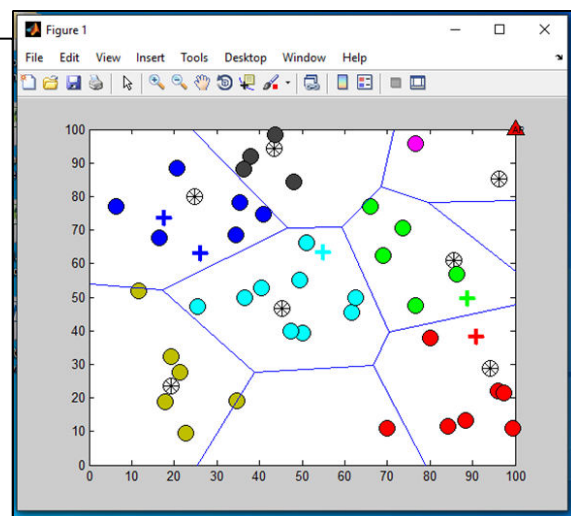


Fig. 2.clustering of sensor nodes using bacterial composition

We considered the duration of the simulation to be 2333 times, the number of sensors or the number of the initial population to be 13, and also Energy depletion is determined by the energy model in [7]. The enduring energy does not

form nodes for both the Genet One algorithm and the Bacterial Composition after clustering shows. Here it is assumed that: All nodes can be selected as headers, Grounding through the nearest plot line for each node or grating through and be the nearest neighbour node. According to the performed experiments, it is determined that sending to the node 100 percent more energy than the neighboring node Spends. Sending through a neighboring node distributes the energy load over the path nodes while each year, directly to the node, one hundred times the energy is directed to the sender, which means that the energy is not used. Uniform energy in the lattice by examining the diagram below, we find that the algorithm combines bacteria with optimal tuning of sensor nodes can only reduce the power depletion of the network, ensuing in a lengthier lifespan. The grid has increased with decreasing energy consumption (figure 3). In the bacterial composition algorithm, the chromosome composition calculation section is deleted; So by deleting this all calculations related to this operator, such as selection, comparison, etc. have been deleted. As a result for comparison number - This algorithm is used by the genetic algorithm from the number of reference parameter to the fit function. The set shows both algorithms as a fit function. According to the diagram of the algorithm of bacterial composition, the fewer visits, the better the answer (figure 4).

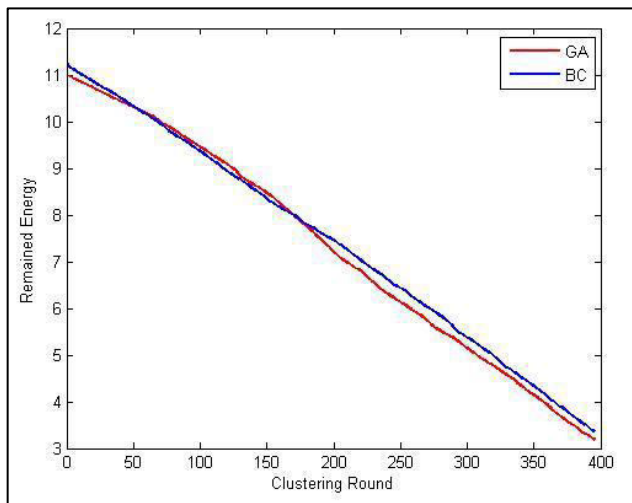


Fig. 3. remaining energy of Network with GA& BC

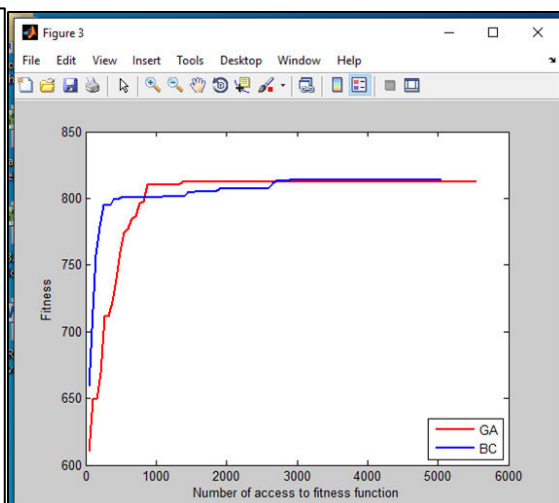


Fig 4. number of references to the fitness function

VII. CONCLUSION AND FUTURE WORK

In this work, two genetic algorithms and bacterial composition for optimal optimization of sensor nodes Mobile wireless is used. The genetic algorithm of the past is frequently used to cluster sense nodes. We used the bacterial composition algorithm that has been used in this field so far. In the Bacteria composition algorithm, the chromosome with the best fit, the chromosome with no best and the chromosome with the worst fit, the chromosome is the recipient. During the algorithm's run, the best and worst fit values are subjective. After the stage Gene transfer, receptor chromosomes and newly created chromosomes enter the competition stage from the first stage chromosome. The output of the algorithm is a bacterial compound. This algorithm has only one input and its response time is fast and considering the number of times to refer to the fitness function, in 11% of cases it has an optimal response to the algorithm. It is genetic. The conclusions of the algorithm's simulation are provided and compared to the results of the genetic algorithm with 13 matched sensors and fixed network parameters in 43 successive runs, which show a 441 percent growth. For optimization, by changing the number of sensors, a growth rate higher than 423% can also be provided.

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BIOGRAPHY

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