Energy Consumption in Point-Coverage Wireless Sensor Networks via Bat Algorithm

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ABSTRACT Sensor nodes spend the most of their limited energy on communicating with environmental information gathered in receivers. Hence, it is important to determine the optimal monitoring sensor nodes and information flow paths to the destination and sink in order to survive the sensor networks. Additionally, the heavy traffic load for transferring packets in nodes closer to the sink increases energy consumption and reduces battery life. It is desirable to reduce the energy between nodes and sink. The main goal is to extend the network lifetime through extending the lifetime of operating sensors as well transferring gathered data from super node to the sink. In this paper, Bat Algorithm (BA) is used to select the optimum monitoring sensor node and resulted path to reduce energy consumption. Simulation results and comparison with other algorithms show the superiority of the proposed algorithm. The simulation results of the proposed algorithm show that the proposed algorithm has been able to reduce the power consumption of the network and increase the lifetime of the network. Also, the proposed algorithm is able to outperform the comparable algorithms on average by 27%.

INDEX TERMS Wireless sensor networks, energy, lifetime, Bat algorithm.

I. INTRODUCTION

Recent technological advances in microelectromechanical systems and integrated circuits have led to the development of small sensor nodes having high processing power and low power consumption. These sensors are used in various fields such as multimedia, medical, monitoring, military, and domestic fields. As an example we can name Handheld computer pagers and cell phones. A set of these sensors is called Wireless Sensor Networks (WSN) which forms a powerful network capable of sampling local values, processing, and sending them to other sensors, and ultimately to the main observer (user). Quality of service is a Combinatory criterion with extensive usages and is one of the network designers' goals, that evaluates many designed [1], [2].

The main challenge in the design of wireless and mobile systems is two-fold: telecommunication bandwidth and

energy. Eliminating these constraints requires establishing new telecommunication techniques in order to increase bandwidth for each user and designing powerful protocols for optimal energy usage. Designs are different depending on the applications and expected capabilities of the system. for example, in many applications, the optimal number of nodes, optimum energy consumption in executive rounds and maximum network lifetime are essential criteria of the network. (In the network categorization, the time interval of the network activity is divided into certain parts so that at each interval, only after selecting the desire category, it is activated for that time, and the rest nodes go off. (This is called a round). One solution to this problem is clustering. In a sensor network, we can organize nodes in small groups named clusters to perform data gathering and data compression.

Each cluster has a central node named Cluster Head (CH) and contains number of member nodes. By clustering, a two-level hierarchy of clusters (at the top level) and member nodes (at a lower level) are formed [3].

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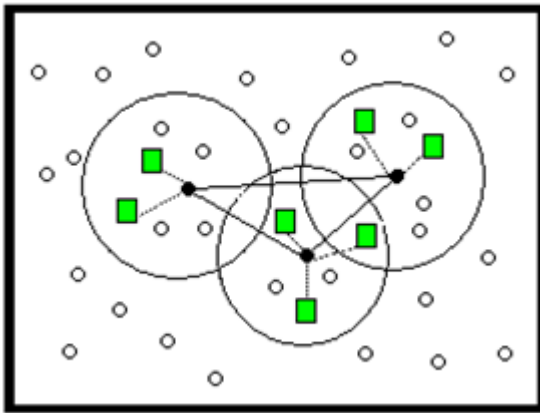
FIGURE 1. An example of a point coverage problem [6].

FIGURE 2. Flowchart calculates the priority of each area.

Since, battery replacement is not possible for many applications, low power consumption is a best choice in these networks and the lifetime of each sensor can be effectively improved through optimizing energy consumption [4]. Power-Efficient designs are common in these networks and are studied according to hardware design and designing of algorithms and protocols in all network layers. One way for reducing energy consumption is reducing the number of sensor nodes in the sensing area, so that identifying each target in the target area is guaranteed. If the network is scalable, the algorithms for reducing the number of sensors can be implemented optimally [5].

In WSN, coverage and quality detection are one of the aspects of quality of service and are divided into three categories: frontier, area and point coverage. In point coverage we are concerned with covering certain points of the environment that are scattered across the surface, their location is predetermined and called the target. In many applications of WSN, due to the limited power of the battery and its inability to replace it, it is very important to optimally select the parameters of the fitting function and select the monitoring sensors to increase the network lifetime [6].

In the point coverage network, the goal is to create coverage among a set of points. Figure 1 shows a set of sensor nodes arranged randomly to cover a set of targets (green square nodes). Connected black nodes form a set of active sensor nodes resulted from a timing mechanism [6]. Point coverage scenario is widely used in military domain, in which, a number of targets with a specific position to be controlled are mentioned. Sensor nodes are distributed randomly at very close distances from targets and send gathered data to the central processing node as follow [6]. At any time, each target is controlled by at least one sensor node, assuming that each sensor can control all targets within its sensing range. One way to reduce energy consumption is reducing the number of active sensor nodes in the coverage area and one way to increase the lifetime of a sensor network is through energy saving by breaking the sensor node set down into several separate sets. In this division, each set should fully cover all targets. These separate sets are activated in sequence, so that at one moment only one set is active [7].
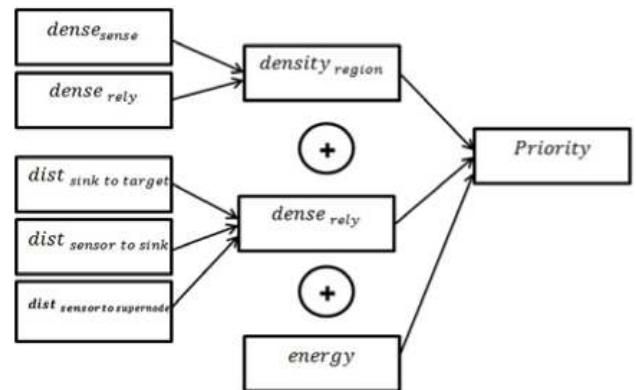
One quality of service issue in WSN is quality assurance through guaranteeing coverage and connectivity factors that constitute the main content of this research. One type of coverage is point coverage, in which the aim is to coverage targets that their locations are already known. Sensor nodes are randomly distributed near targets and at any moment, each target must be covered by at least one sensor node. If some points are not covered by any sensor node, covering holes determined. When only one point of monitored points goes out of the cover, network lifetime is expired. When the sensor network fails to create desired monitoring quality, using additional nodes to solve this problem is an interesting solution for researchers [7].

In recent years, the importance of WSN has increased simultaneously with their application in various fields. Due to the limited power of nodes in WSN, many challenges appeared regarding the lifetime of these networks [8]. Since, it is necessary to consider energy saving algorithms in the design of long-lasting sensor networks, in recent year's attention has been focused on intelligent and capable tools such as heuristic and meta-heuristic methods in order to reduce energy consumption in sensor networks. Given that each of the energy consumption optimization methods has their own position in problem solving and taking into account problem conditions, we can achieve an optimal solution by using Bat Algorithm (BA). This algorithm has an important position among different optimization methods; therefore it is expected that the proposed method gains better solutions in terms of quality, sustainability and energy consumption balance as well make better choices to increase network lifetime so that results compete with other methods [7]. The purpose of this paper is to determine at least required additional nodes and their locations such a way that energy is used optimally. Considering that this problem is an NP-hard problem, BA will have a good performance.

The paper is organized as follows: In Section II Related Work is provided. Section III the proposed algorithm is explained, Section IV describes the simulation results of the proposed algorithm in detail and the conclusion is presented in Section V.
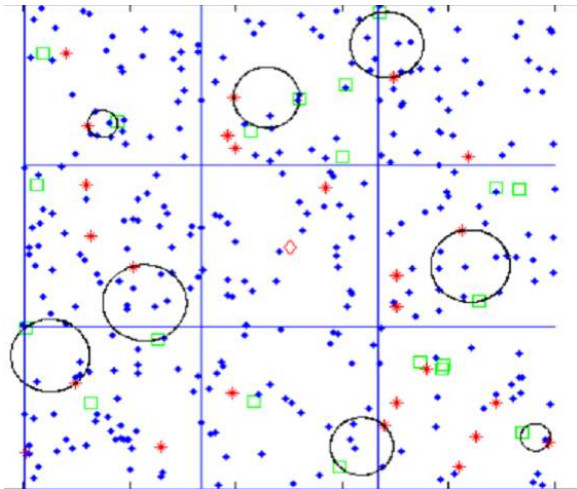
FIGURE 3. How to calculate the relay density.

FIGURE 4. Normal node layouts, supernovas and targets in the environment.

II. RELATED WORK

A. POINT COVERAGE PROBLEM

The probability that an incident in a region is occurred in a specific time period is called network coverage power [1]. In addition, provided schemes for coverage consider the weaknesses of a sensory field and then propose new schemes to improve the overall quality of network services [1]. Another important issue in using WSN with coverage is connectivity [2]. In point coverage, the aim is only covering certain points in the environment, and these points are dispersed in the environment. In all these methods, the points and their locations are predetermined and called 'target' [2]. In point coverage, even if all the targets in the environment can be covered, if there is no connection between the sink and sensor nodes to transmit information, no work has been done practically [2].

Many researches have been done on power-aware algorithms and energy consumption optimization. Carbunar *et al.* [8] proposed a method for energy saving by detecting the position of sensor nodes and reducing their overlap. In [6], a method for saving power consumption is presented, which first divides each region into two categories and only one category is active at a moment, then active and inactive processes are repeated alternately.

The method presented in [7], first activate and inactivate nodes distributed, so that the desired coverage range is obtained and doesn't change. In networks, in which nodes are statically distributed, heterogeneous energy distribution problem is occurred. In fact, the closer the sensor is to the target, the greater its energy consumption, so network connectivity and coverage are not fully guaranteed [9]. In [10], a method is provided for achieving scalable coverage when the overhead and computational complexity is high. The aim was to increase energy efficiency.

In [11], at first sensor nodes are distributed randomly and then a self- healing algorithm creates full coverage. Energy efficiency is obtained by performing an energy optimization algorithm. 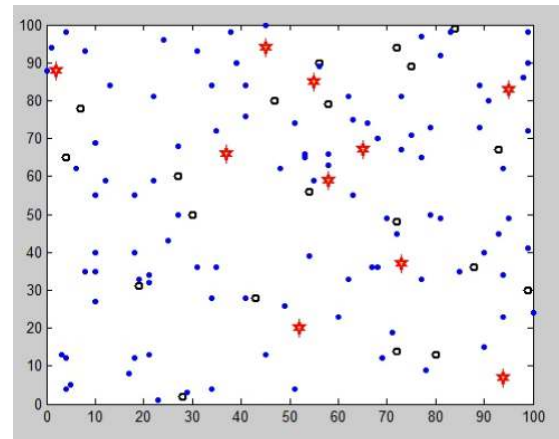Simulation results confirm the efficient energy consumption in this network than the early distributed network. In [12], energy consumption reduction through reducing energy consumption on the boundaries of covered region is proposed. In [13], a method is proposed to reduce the number of sensor nodes, in which biological algorithms are used for energy consumption reduction purpose. The advantage of this method over other ones is its uniform distribution of sensor nodes. In [4], increasing network lifetime through maximizing the number of sensor categories is proposed, in which, a node is allowed to be in more than one member group, which in turn increases network lifetime. In [14] network becomes resistant to the failure of a node by using data transmission in several paths. In this way, each node determines its next jump according to the node that has the highest residual energy.

In [15] a clustering method based on the maximum delay, energy consumed by the middle nodes and cluster size is proposed. This algorithm works by constructing a spanning tree, the root of which is the cluster head node. In another study [16], unlike other researches, Authors didn't consider the sensory range of a disk with constant radius around the node and proposed a scheme for reducing power consumption utilizing the cooperation between nodes. In [17], Authors formulated data compression problem in wireless networks based on the energy. In this model, a percentage of the data of each sensor node is not sent based on data correlation, so energy consumption is reduced. Authors found that the greedy method is the most efficient one for energy consumption.

In [18], the purpose is distributing some interface nodes in network in order to increase the network lifetime. In [19], authors have used hierarchical clustering to reduce energy consumption of WSN. Energy used for connecting each node to the processing center is reduced by using CH. Many researches, such as references [5]–[8], have provided clustering methods to reduce the number of clusters. In addition, in [4], several greedy protocol based methods have been proposed to reduce power consumption and increase the lifetime of a target coverage network. In [20], authors compared the

shortest path clustering algorithm and greedy algorithm for relay selection. In the proposed method, groups of nodes without a manager node are merged into other groups and this process repeats until all groups have a manager node. But it is not an optimal method to reduce network energy consumption unless having little telecommunication and computational complexity.

Another method [20] is the shortest path algorithm, in which each active node in the current round finds its shortest path to the nearest manager node. Choosing the shortest path cause to reduce network energy consumption, but it's not an optimal method to reduce the overall energy consumption.

III. THE PROPOSED ALGORITHM

In recent years, the advancement in telecommunication technology and electrical and electronic industry has led to manufacturing small and fairly cheap micro sensors connected together through a wireless network. These networks, which are called WSN, have become a good choice for extracting data from the environment and monitoring environmental events.

WSN, due to their own technology, and using limited batteries have a limited lifetime, and if the battery fails or the sensor is positioned somewhere that cannot be accessed, that sensor will no longer be usable. So, measures must be taken to reduce the energy consumption of each sensor and subsequently increase the lifetime of them. In this regard, many studies have been carried out which highlight the importance of this problem. Some of these studies use nature-inspired algorithms which are inspired by collective behavior of living organisms.

A. PROPOSED SCENARIO

Coverage has various types: regional coverage, point coverage and barrier coverage. The focus of this research is on the point coverage. In a point coverage network, a number of targets with a specific location to be controlled are considered. A large number of sensor nodes are randomly distributed near the targets and transfer information obtained using the interface nodes to the manager node. At any moment, each target must be controlled by at least one sensor node. In a point coverage, network is alive until all covered points are monitored, which is lifetime definition. When only one point of the monitored points goes out of the coverage, network lifetime has expired. It should be noted that the activation of the monitoring nodes is not sufficient for covering and the existence of a path for data transmission is also important. Therefore, even when all targets are covered, if there is no path for transmitting data from monitoring nodes, network lifetime is expired.

WSN fails to create optimal monitoring quality, using additional nodes to solve this problem is an interesting subject for researchers. The aim of this study is to increase the lifetime of a point coverage sensor network and optimal placement of nodes in the network such a way that covers network weaknesses in order to maximize the lifetime of the sensor

network. It is assumed that the network consists of n nodes named s_1 to s_n. The network also includes S_u supernodes named S_{u1} to S_{uM}. It is worthy to mention that the number of supernodes is lower than the ordinary nodes (m<n). In the scenarios, sensor nodes and supernodes are randomly arranged. After performing the algorithms provided in the network, sensor nodes must be in such a way that guarantees the following conditions:

- There are Ta_1 - Ta_i target to be covered always
- There are s_{1-} s_n monitoring nodes arranged randomly
- There are S_{u1-} S_{um} supernodes arranged randomly

B. NETWORK ASSUMPTIONS

- Each node in the network has a unique ID.
- Nodes are not aware of their position and coordinate.
- The number of supernodes is much lower than the ordinary nodes.
- The energy of the supernodes is more than ordinary nodes and is considered on multiple scales.
- All supernodes have the ability to communicate.
- Supernodes synchronization is done through central station and other nodes' synchronization is done through manager node.
- Nodes have the ability to change transmit power and set transmitter power according to the distance increase and decrease.
- Also, nodes are able to detect the distance based on the energy of the received signal
- There are i targets with fixed positions in environment to be covered. The network consists of supernodes, sensor nodes, and targets.

C. ENERGY CONSUMPTION MODEL

The energy model of sending and receiving 1 bit of data is as LEACH energy model [1]. Assume that the distance between transmitter and receiver is d, if d is greater than d_0, then the multi-path model (with path loss factor 4) and otherwise open space model (with path loss factor 2) is used. This Equation is as follow:

$$E_{TX}(l, d) = E_{TX-elec}(l) \times E_{TX-amp}(l, d)$$
$$= \begin{cases} lE_{elec} + l\varepsilon_{fs}d^2 & d < d_0 \\ lE_{elec} + l\varepsilon_{mp}d^4 & d \geq d_0 \end{cases} \quad (1)$$

where, E is the energy required to activate the electronic circuits, and ε_{fs} and ε_{mp} are both power amplifier activation energies for both multi-path and open space conditions. A more general form of this equation is expressed by Equation (2) with constant coefficients p and q.

$$E_{TX}(l, d) = p \times qd^n \quad (2)$$

In the asymmetric grid, the initial energy of the nodes of the multiplier manager is considered to be the initial energy of the ordinary sensors. The energy consumption of the monitor node in each run is called Es_1.

D. SYSTEM SPECIFICATIONS

- The point coverage network has a heterogeneous structure, using two types of sensors. A group that has fewer capabilities is called normal nodes and another group that has more functionality, called supernodes.
- The target network consists of *n* sensors; distribution is all in the form of nodes randomly.
- All manager nodes are connected, at least one path from the admin nodes.
- The sensor node has an initial energy of *E*, an *Rc* communication path, and an *Rs* sensing range.
- Sensors can communicate with each other and with the super nodes if their Euclidean distance is less than *Rc*.
- Each node can be an interface, a sensor, or both.
- Each active sensor node must send its information through the interface nodes to at least one supernode.
- Schedule and roaming network.

E. THE METHODE ALGORITHM

The routine of the proposed algorithm is that the nodes after they are deployed in the environment to monitor the goals in the network. Given the limited sensors 'energy and the random setup of the nodes, after a period of time, the nodes' lifetime is completed or at the end of the completion In order to increase the lifespan of the node placement operation, it means that in the fracture areas a number of nodes are added and the network re-establishes life. Since the most important and influential factor in network lifetime is energy, the parameter used in this algorithm is based on the optimal energy consumption. In fact, the remaining energy of each node and the average energy remaining around each goal are the basis for decision making in this scenario. Other parameters that implicitly influence the selection of the nodes are: the amount of energy left by each node to the total energy, the number of goals that each node represents, and the distance between each node and the supernode. These parameters are considered using the BA to select sensor sensors.

The proposed algorithm starts when the relative life of the network is over. After a relative time period when the targets were monitored, the nodes' energies are on the verge of completion and the network life is about to end. In this scheme, the division and conquest method has been used, so that the area is divided into smaller regions, then each region is individually examined for finding weaknesses.

First, the network is divided into nine areas, and then it uses the proposed formula explained below to prioritize each region, which uses this priority to reject the decision-making process of the proposed algorithm. To determine the priority value of each region, the following Equation is first calculated for each region separately. The result sets the priority of each area (3)–(6), as shown at the bottom of the next page.

The parameters used in this formula are as follows:

ε**:** presence or absence of target in the target area and can be 0 or 1.

$dense_{sense}$: Sensor density expressing the number of active and living nodes in the area.

$dense_{rely}$**:** the density of the relay, in each region we find for each target the nearest supernode; in the middle of the supernode distance to the target, we consider the center of the circle and half the distance to the radius of the circle, and draw a circle supernode and target are placed on its environment. Then count the number of sensors in this area and divide the result into circular area.

Density: The total density of each area computes the sensor density and the relay density.

$dist_{sink\ to\ target}$**:** Goal distance in each area to the sink.

$dist_{sensor\ to\ sink}$: Average distance of sensors in each area to the sink

$dist_{sensor\ to\ supernode}$: Average distance of sensors in each area to the nearest supernode

Distance: The total distance between the nodes of each area to the sink and the supernode and the average distance between the targets in each area to the sink.

$energy_{node(i)}$: Identifies the remaining energy of each node within the region.

Energy: Means the remaining energy of the nodes in each area.

Priority: Specifies the priority of each area.

The coefficient ε has two values of 0 or 1 that indicate the presence or absence of a target in the area in question. A region that has no purpose is set aside and the value of the priority function will be zero for this area. The most important criterion in the lifetime of the sensor network is density and has a direct impact on life expectancy. Due to the random distribution of sensors, the number of sensors around a target may be very low, in this case, the same target causes the network to die in low gears. Another important factor is the relay density, the reason for the effect of this is the role that the transmission of information in energy consumption, the more in between the target to the nearest supernode, there are more interface nodes, the energy consumption of the sensor nodes will be less. Another important factor is the distance. Simulation results indicate that targets that are far away from the sink lead to the death of the network. Another criterion is the average distance between the sensors of each area and the nearest supermodel and sink. In fact, the distance between the sensors and the supernode is important when their distance to the sink is high. The amount of energy used to transmit information from sensors to the nodes of the manager is closely related to the distance. If this distance is less than the sensor radius, it reaches power 2, otherwise the power is 4, so the effect This criterion is obvious in choosing the right area. At the end, the three regions that have the highest and opposite zero for Equation (4) are selected as the target area, which is the basis for the search for the sensor placement, and the other areas are set aside. Since the network life span is directly dependent on the nodes' energy, the remaining node energy parameter also plays an important role in determining the priority of the node.

For this reason, the smaller the total amount of energy remaining in a region, the higher priority should be given to that area, so that the network lifetime increases by placing

new nodes in that area. The above figure shows how to divide the area into 9 regions and calculate the relay density for each area. In the above form, the blue points of the common nodes, the squares represent the targets, and the red stars represent supernovas, and the rhizome represents the sink.

F. TERMINATION CONDITION

The termination condition in the proposed algorithm is to not improve the solutions over a predetermined number of generations. It means since the last time the algorithm finds a new optimal solution, the algorithm is repeated n times but if it cannot find the optimal solution, the algorithm is stopped and the best solution is displayed.

The general steps of the proposed algorithm are as follows:

1) The coating algorithm in the sensor network is scheduled and routed using the BA and continues until the relative death of the network.
2) After the network is in a critical phase, we divide the area into nine areas.
3) Use the formulas 3, 4, 5 and 6 for each priority area. The area that is more on the brink of failure will have a higher priority, with the addition of new nodes, the failure of that area will be postponed. For the three regions with the highest priority for the above formula, we find the optimal location of the nodes using the geometric method.
4) In the three areas of the province, new nodes are added as randomists.
5) The network starts up by adding new nodes and targets are monitored within the network.
6) The network continues to operate as long as the first purpose of the monitoring is over.

IV. SIMULATION RESULTS

In this section, the output of the simulated program for the network is given for the same conditions as the other articles for comparisons. MATLAB software is used to simulate this project and the network environment. The energy model used in these simulations is the energy model, which is given in reference [21]–[23].

The proposed algorithm starts with the deployment of nodes in the environment. The nodes are monitored for a

TABLE 1. The values used in the simulation [22].

Parameter	Value
Network size	500*500m
Supernods location	Random
Nods location	Random
Nods Initial location	0.1J
Supernods Initial Energy	0.5J
Communication range	90m
Sensing range	60m
Number of nods	300
Number of Supernods	25
Number of target	20
E_{elec}	50 nj/bit

number of purposes in the environment that these monitoring nodes are called normal nodes. Also, in order to optimize energy use, a number of higher-power nodes are also placed in the environment, which is referred to as supernode. The presence of two groups of sensor with different abilities places the proposed network in the category of heterogeneous networks. Normal nodes are referred to as ''limited energy'' sensors, which are only used to monitor targets. In order to save energy on these sensors, only a few sensors are monitored in each round and the rest are in sleep mode. Supernovas are sensors with a higher ability to both initial energy and sensory radius. Supernunts are used to send snuff sensors and transmit data over longer distances. Using supernodes in the role of the relay, it saves a lot of energy and improves the life span of the network.

The following figure shows the arrangement of normal nodes, supernovas and targets in the environment.

Red-starred targets and blue circles indicate nodes and black circles of super nodes.

The proposed algorithm starts when the relative life of the network is over. After a relative time period when the targets were monitored, node energies are on the verge of completion and the network life is about to end. The values used in the simulation are shown in Table 1.

A. PARAMETER SETTING

The parameters of the proposed algorithm are defined as follows: The number of bats that is set by the user for each problem. Number of generations or number of bat movements

$$density = dense_{sense} + dense_{rely} \tag{3}$$

$$distance = \frac{\sum_{i \in number\ of\ targer} dist_{sink\ to\ target}(i)}{number\ of\ target\ in\ region}$$

$$+ \frac{\sum_{j \in number\ of\ sensor} dist_{sensor\ to\ sink}(j) + dist_{sensor\ to\ supernode}(j)}{number\ of\ sensor\ in\ region} \tag{4}$$

$$energy = \frac{\sum_{i \in number\ of\ sensor} energy_{node(i)}}{number\ of\ sensor\ in\ region} \tag{5}$$

$$Priority = \varepsilon \times density \times \frac{1}{energy} \times distance \tag{6}$$

TABLE 2. Parameter setting.

Pulse emission	Loudness	Number of generations	Number of bats
starts from 1 and gradually reaches to 0	0.95	2000-3000	40-200
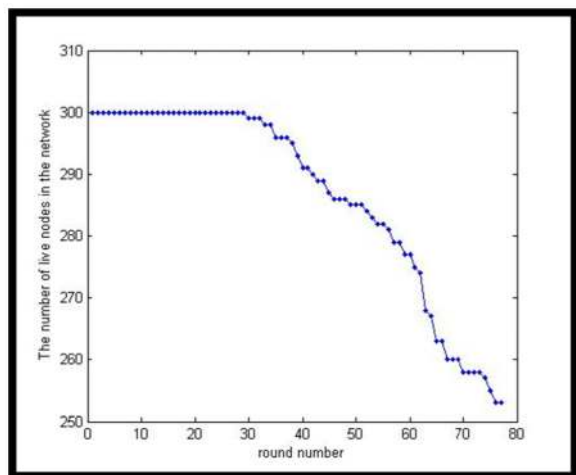
FIGURE 5. Number of live nodes per round.
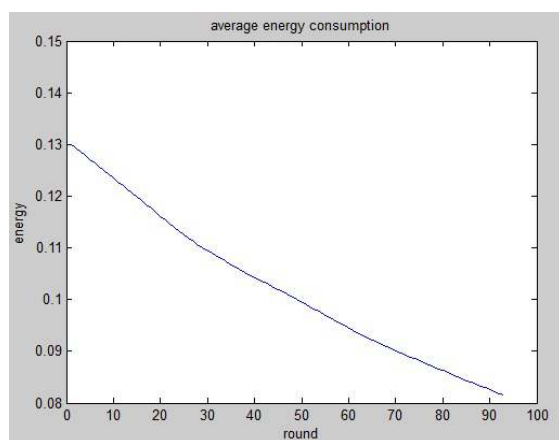
FIGURE 6. Average energy consumption.

FIGURE 7. Energy consumption.
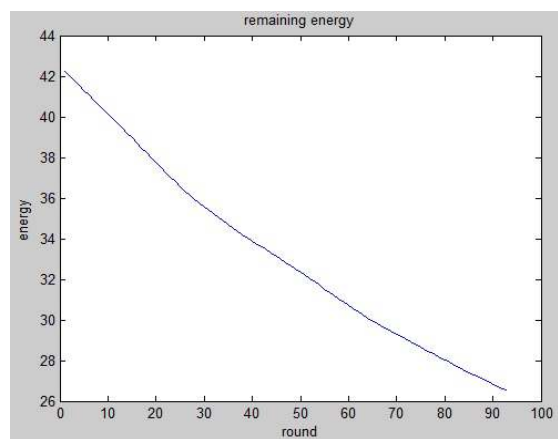
FIGURE 8. Total energy remaining.

set by the user for each problem. Loudness which is set to 0.95. Pulse emission starts from 1 and gradually reaches to 0.

B. EXAMINING THE SIMULATION OF THE SELECTION ALGORITHM FOR SENSOR SENSOR NODES

For a better comparison and understanding of the conditions of the proposed algorithm and hence the correct conclusion, it is necessary to change the network parameters. Also, in order to find out whether a grid algorithm will respond appropriately and whether the network is scalable or distributed, we must change the network conditions from the dimensions and the number of tests.

In the proposed algorithm, the selection of active sensors is performed by the BA. According to the cost function defined

in this algorithm, in each sensor array, based on parameters such as residual energy, distance to the nearest supernode, distance to the sink, the number of targets in the sensor radius, and a probability function to either or both of the sensors Priority is assigned. Sensors with higher priority of the candidate are activated. Among the sensor candidates, the sensor of the highest priority is selected as the active sensor, and the rest of the candidates remain in reserve mode. Active nodes are awake and the rest are in sleep mode. The use of the bat competition algorithm results in faster network connectivity and the selection of the best nodes for activation in each round. Due to the wide scope of the problem and the NP-hard of the active node selection, the bat competition algorithm shows good performance in this regard.

- **Part I: Before adding energy to the nodes**

Figure 5 shows the number of live nodes in each round. As you can see, all sensors are alive in the early stages. As the network continues, the number of live sensors is gradually reduced. The reason for the sudden death of sensors, the proportional distribution of the load on the network, and the selection of active sensors is such as to prevent the early death of the network. By switching the role of the active sensors and
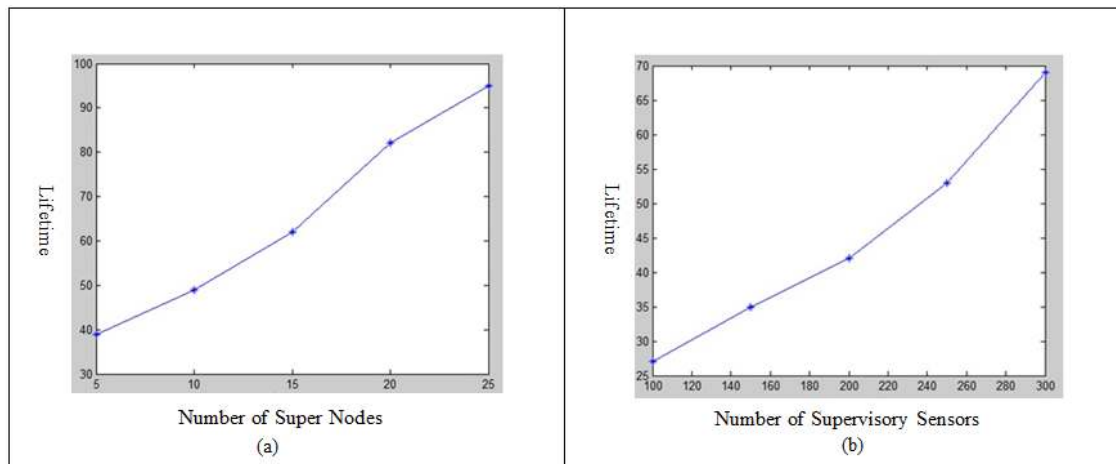
FIGURE 9. The amount of lifetime change in the network a) for increasing the manager nodes b) for increasing the number of sensor sensor nodes.

selecting the sensor with a blatant priority, the active energy sensor is approximately the same distributed in the network and the sensor's death is gradually taking place.

Figure 6 shows the average energy consumption and Figure 7 shows the amount of energy consumed per round.

Considering these conditions, in which different sensors are activated per cycle, and sometimes some sensors are responsible for monitoring multiple targets, the amount of energy consumed varies over different periods, and this trend is a decreasing trend, because with the death of priority nodes, other nodes are selected as active nodes and their power consumption is far higher.

The following figure shows the total amount of energy remaining in the sensors in each round. As you can see, this amount remains more and more gradually, and in the foregone periods, this decreases.

- **Part II: Adding energy to dying nodes**

The sensor network continues to cover the targets. After a period of time, the number of nodes near some targets will end their energies, and as soon as the first objective of the monitoring is over, the network life span ends, trying to improve the life span of the network by keeping the dying nodes around the targets alive. For this purpose, first, the network environment is divided and priority is assigned to each region from these areas, and according to these priorities, the three regions in which the energy of the nodes around the target is lower is selected and in each region to the node Dropout energy is allocated. This lifetime will increase network lifetime and improve network energy efficiency. Figure 9(a) shows the length of the network time for changing the number of nodes in the manager or cluster. The rising trend of life expectancy for increasing goals in this figure indicates the ability of the proposed algorithm under different conditions and network scalability.

In sensor networks, changing the number of sensors will allow for widespread changes in the performance of the
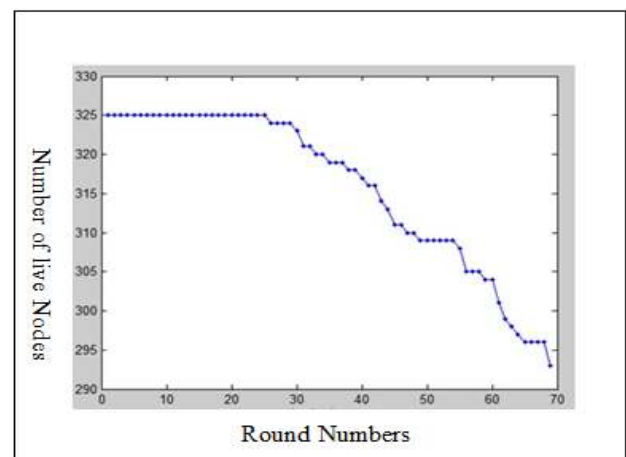

FIGURE 10. Number of live nodes in the network in different drives.

proposed algorithms. As seen in Figure 9(b), the number of nodes in the network has been changed from 100 nodes to 300 nodes. The increase in network lifetime by increasing the number of nodes from 100 to 300 nodes with a constant number and the same position of the goals and nodes of the manager indicates the correct implementation of the proposed algorithm. Figure 10 shows the number of live nodes in the network in each run of the algorithm. In this figure, there are no nodes in the first 25 stages, and the number of nodes in the network has gradually increased with the completion of node energies, which has led to the end of the overall life of the network. With little attention being paid, with the death of about 15% of all nodes, the life of the network is also over. A solution can be proposed to avoid this problem and increase this percentage. The proposed strategy is first to find nodes in the network that have not been used for any of their current location, and then relocate their locations to nodes that have been killed by their deaths.

If possible, multi-purpose coverage with a single sensor node is much more cost effective than any sensor will monitor
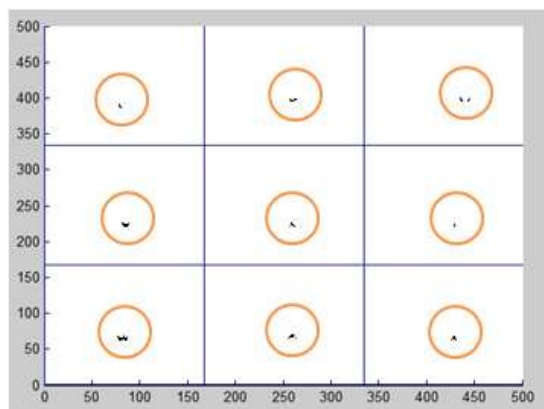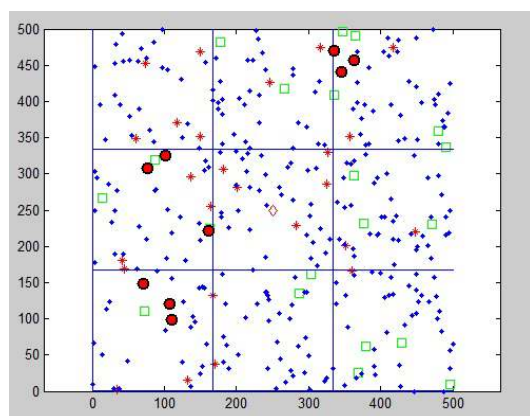
FIGURE 11. Area.

FIGURE 12. Low energy nodes in priority areas.

FIGURE 13. Total energy before and after energy addition.
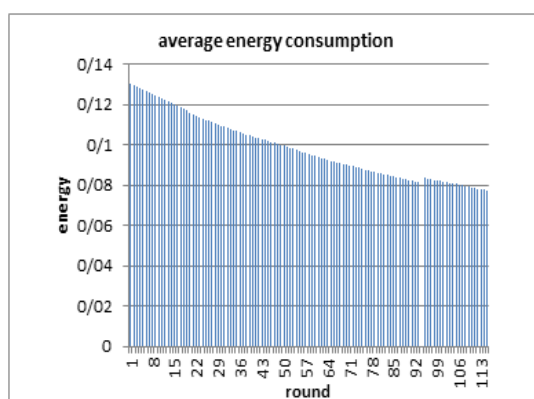
FIGURE 14. Comparing the average energy before and after adding energy.

only one target. In group supervision mode, targets by a sensor node, instead of reducing energy to the number of targets, only add up to a percentage of that amount of energy for this group monitoring of the corresponding sensor node, which will reduce network power consumption.

C. AREA

Figure 11 illustrates show the network environment is organized. The nodes determine, according to their geographical location, which region they belong to. After the nodes are identified in each area, the number of targets in that area is determined for each area. Then for each region, based on the number of targets, the mean energy of the nodes, the total mean of nodal distance from each region to the sink and the supernode, and the average distance between the targets in each area to the sink, the total density of each region includes the sensor density and the priority relay density to each area Is allocated. Based on the calculated priority, the priority of each area is determined. Then 3 areas with the highest priority are selected for energy injection.

After determining the priority areas, among the nodes in that area, nodes that have less residual energy and more targets can be monitored. To the selected nodes, the energy
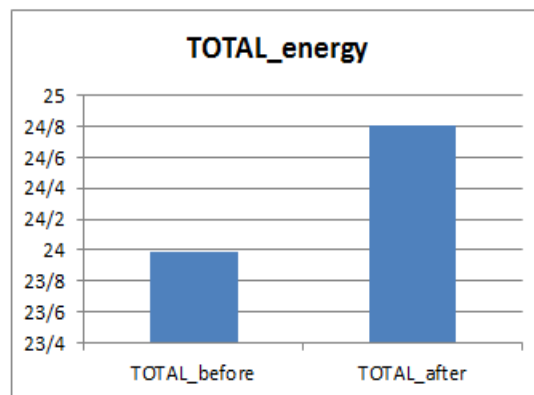
injected and the network with the new injected energy continues to monitor the targets. Figure 12 shows low energy nodes in priority areas where energy should be added to them.

After adding energy to some of the nodes, the network rescues from death and continues to work. The amount of energy added to the network and its effect on life expectancy are shown in Figure 13.

As seen in the diagram above, adding energy to some nodes has increased the total network energy by about 1%. The number of nodes that are selected to add energy is small compared to the total number of nodes, but due to the addition of energy nodes with very little remaining life, the energy will be increased by an average of 1% Became.

Figure 14 shows the average energy of the grid in different periods before and after the energy is added. The chat created in Round 92 indicates the end of nodes around the end of one of the targets and the end of the network, and after adding energy to a number of droop nodes, the network has a new life and is up to 113 and it continues its work. The downside of the chart represents energy consumption in each round to monitor targets.

Figure 15 shows the amount of remaining energy in total nodes per round. Since the lifetime of the regulatory network is subject to continuous monitoring of objectives, as long as one of the objectives is removed from supervision,
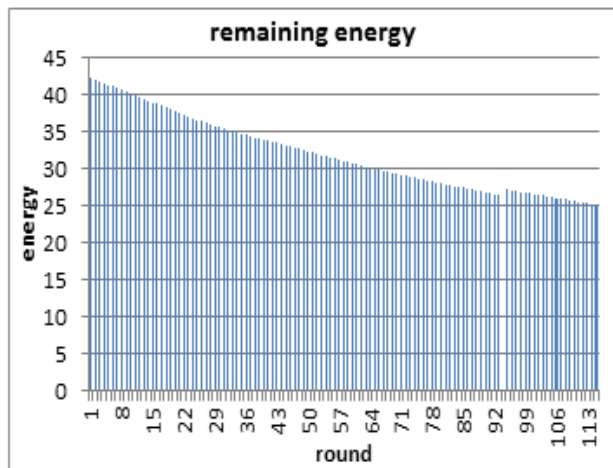
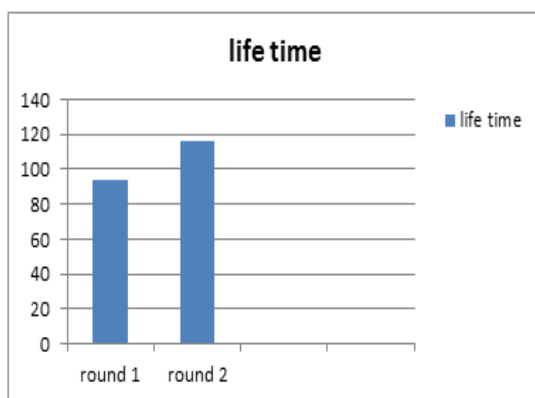**FIGURE 15.** Comparing the remaining energy before and after adding energy.

FIGURE 16. Lifespan before and after the addition of energy.

FIGURE 17. Compare network lifetime before and after adding energy.

the network life will be completed. That's why about 50% of the energy remains in the network. After adding energy to drowning nodes, the network's remaining energy has increased, but due to the optimal selection of nodes for increasing energy, the remaining energy remains in the network and is wasted. By choosing optimal nodes to increase energy, it prevents useless energy consumption and, as shown in the graph above, results in energy efficiency.

As mentioned above, the goal of increasing energy to nodes is to add network lifetime. By choosing the right nodes for energy injection, the life span of the network is expanded, resulting in higher output power. The chart below shows a 20% life span.

The figure above shows the proposed network lifetime before and after energy addition with the EEDG algorithms [24] and EDTC [20] shows an increase in the number of targets.

As the number of targets increases, the number of nodes involved in the monitoring increases, resulting in more energy per consumption, resulting in a 77% reduction in network lifetime. Also, in each network, with the number of specific objectives of the proposed method1 algorithm, due to the
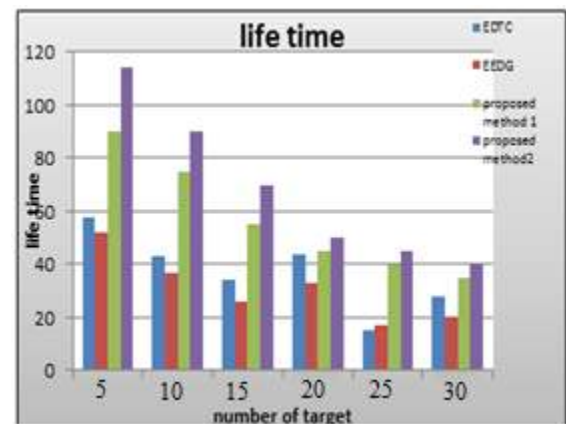
optimal selection of the active nodes in the first and also in the proposed method2, by selecting the appropriate nodes for the injection of energy in the second region, indicates the increase in network lifetime compared to the two algorithms Has been raised.

To evaluate the performance of the proposed classification algorithm after simulation, the proposed algorithm is compared with MSS [21], GSA [22] and MSACO [23] algorithms. It should be noted that [23] has compared his proposed method to the selection of sensor with two other algorithms and showed superiority of their method to them. As shown in Figures 18, 19 and 20, in the proposed algorithm for the selection of monitoring sensors, the network has a longer life span than the MSS algorithm presented in [21] and the GSA algorithm, as described in [22] and MSACO [23] is provided. These methods are compared in each report with other methods, and their superiority has been shown from other methods provided by that time.

Assuming the selection of identical monitoring nodes in all three algorithms whose results are given, it is seen that the average length of the network in the implemented method is superior to other methods. Figure 18 shows that the energy consumption of the grid in the proposed algorithm in most drives is less than three MSS, GSA and MSACO algorithms. Also, according to Figure 18, network lifetime for multiple simulations and intermediate and normalization of outputs are more than the two algorithms presented. It is interesting to note that if the total remaining energy of network nodes after the death of the network is comparable to the parameters, as shown in Figure 19, the grid in the proposed algorithm, although the GSA algorithm has energy, but has a longer lifespan, this is an advantage.

In Figure 20, the length of the network is shown in terms of the number of targets in the network. In the long run, according to the target, expected to be descending. The reason for the deformations obtained is also the change in the network topology and re-ordering for the change in the target number. As shown in Figure 20, on average, the proposed algorithm has a longer lifespan than three other algorithms.
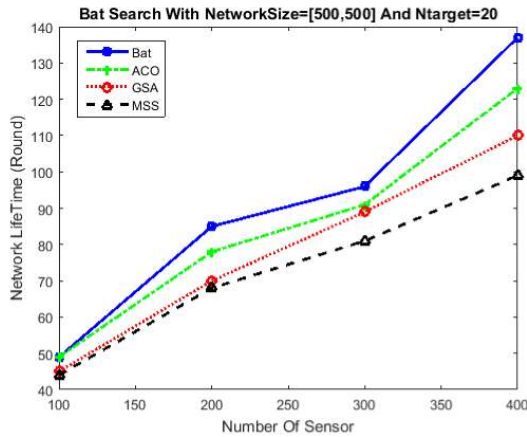
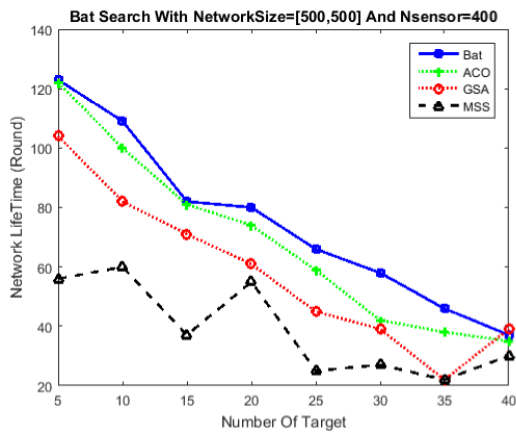**FIGURE 18.** Network power consumption in different drives and comparison with other algorithms for 20 targets.

FIGURE 19. The amount of energy remaining in the network with 400 nodes in different drives and compared with other algorithms.
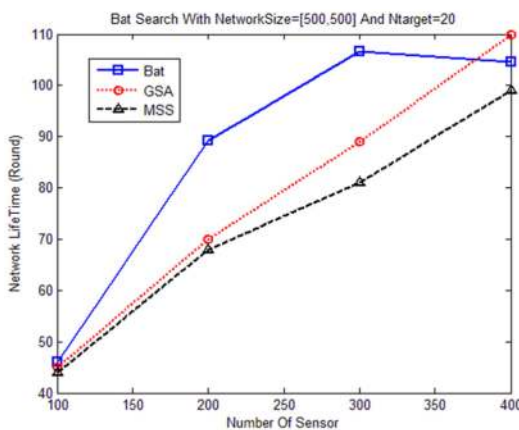

FIGURE 20. The amount of change in network lifetime by increasing the number of sensors by 20 targets.

The proposed algorithm is more than all other modes for all modes.

The amount of energy consumed per run cannot be taken as a benchmark for itself, but the average energy consumption from the beginning to the end of a network is a very important parameter in increasing network lifetime. If the amount of energy consumed in the network in each run reaches its minimum, it can be stated that the network life span will increase relative. By balancing energy from different areas in the network, the energy remaining in the network is longer when the network life is over. In some cases, we want to rearrange some of the nodes in the network, and the amount of energy remaining after the network's death is important in this regard.

V. CONCLUSION

In this paper, the BA is used to select the optimal sensor and the resulting route to reduce energy consumption. The main goal was to extend the network lifetime by extending the life of the operating sensors, and the data collected by the super node would be sent to the well. Due to the simplicity and flexibility of the simple implementation of the BA, this algorithm was selected. The results of the proposed algorithm were presented with different values of the parameters. The results indicate that the algorithm is scalable; that is, the algorithm responds appropriately not only for a particular state, but also for different network states. Finally, the results of the proposed algorithm were compared with MSS, MSGSA, MSACO, EEDG, GSA and EDTC methods. The results of simulation and comparison with other algorithms show 27% superiority of the proposed algorithm.

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