

AN OPTIMAL ENERGY MINIMIZATION ALGORITHM FOR WIRELESS SENSOR NETWORKS USING GRAVITATIONAL SEARCH, COLONY ALGORITHM

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Abstract

Real-time traffic configuration is critical for networking planning and development in the technology industry, especially for mobile or wireless network performance evaluation. A wireless sensor network (WSN) is made up of a vast quantity of devices that are uniformly spread around a particular location. In this research study, a Gravitational Search Algorithm (GSA) based model is proposed to improve CH selection. To improve the energy efficiency further, a modified GSA is proposed for routing to the base station. This research focuses on a network to lifetime maximization using proposed algorithms. They perceive the world within their respective ranges and relay the information to one another using a cellular method and multiple hops techniques. The current conventional techniques were analyzed and the analysis was interpreted to find the errors and make the network's energy. To ensure WSN nodes still have current and making progress toward that goal, we place requirements on the current and total counts, with the objective of balancing energy use across all domains. This would cause a large reduction in electrical demand and also experiment of this proposed model is compared with the artificial bee colony (ABC) procedure.

Keywords: Wireless Sensor Network; GSA, Link Energy Minimization; Energy Efficiency.

1. Introduction

A WSN is made up of sensors placed at variance or by hand to detect natural environment or structural incidents and transmit the data gathered to a ground station. In isolated places, a vast number of cheap, lightweight, and best routes are typically installed haphazardly. The routing protocols used in WSNs are designed to save power and therefore extend the channel's life span. The contemporary need is for the growth of multipurpose, relatively low, and low-power sensors [Andreea A, Corici, (2020)]. Data rates ranging from 64 kbps to 120 Mbps are accepted. All the data is compressed and then sent over the selected medium at the proper time, with the help of an Expand Accelerator (similar to a Compressor/expander). Three distinct components comprise the GSM network [Buscheck TA et al., (2019)]. The GERAN (UMTS), the access network (3G), and the backbone of the system; however, the roles of Network Subsystem, Base Station, and Support are somewhat intertwined in the enterprise today. One, Between the Base Station of the Base Transceiver (BTS) [Dutta UK et al., (2018)]. and the Mobile Switching Centre (MSC), and A-bis application interconnection between the BTS and BTS are the three most commonly applied frameworks two, information is present in the air interface: Physical Channel and Logical Channel, which is represented by the data found on the physical Channel. Segmentation refers to the process of dividing information into various sections [Wibowo WW et al., (2018)]. The primary goal of differentiation is to refine and transform an object's interpretation into something more significant, as well as to make the image easier to interpret. Its purpose is to discover artifacts and borders in photographs. Image segmentation is a technique for assigning a label to each pixel so that units in an illustration share similar features. Grouping is a differentiation procedure that divides data into multiple groups depending on certain features [Ziafat H et al., (2014)].

In a decision-oriented application, the segmentation process is one of the most frequently used techniques for correctly classifying the feature of an image. It segments an object into distinct areas of high correlation among pixels in each range of the spectrum contrast between locations [Dhungana D et al., (2011)]. It's useful in several areas, like healthcare services, image processing, ambient image processing, and pattern classification. Texture analysis strategies include cut-off point, edge-based, constellation, host-based, and network approaches. Aggregation is among the most effective processes among the various techniques. K-means grouping, Fuzzy C grouping, mount clustering technique [Hemp A, (2011)]. and parametric segmentation method is all examples of grouping. K-means clustering is a popular clustering method It is easier to use and quicker to compute than hierarchy aggregation Based on the findings of the previous study, K-means correlation-based, and K-medoids agglomerative algorithms are being used in a survey to segment leaves for disease detection [Arbin N et al., (2015)]. In recent days, current metering technology has developed in an advanced manner with a more reliable smart energy reading structure. Automated Meter composing (AMR) system is used to only look at the meter readings to see how much energy you're using. For minimizing error in transmission and to optimize the speed and data integrity, a MIMO system is largely employed which consists of compound transmitters for both transmission and the last part of the recipient. Space-time coding techniques are used in relay strategy for co-operative wireless communication improving the coverage of a 5G wireless network. Some of the above methods are also used in several other applications, and a few of these were first brought about by this study. Fair Price Shops will aim to distribute food grains to those eligible for the Public Distribution System (PDS) to the populace at the least cost of subsidy [Khera R, (2011)], or at the best prices possible (FPS). When it comes to countries like India, which have a high poverty rate, the provision of basic goods, even though it does not cover the essential needs of the population, still goes far enough to enable those families to escape from poverty is crucial. Ration systems that are still in India rely on manual measuring quantities and the transactions already require a lot of maintenance, thereby adding more to their complexity [Chakraborty S et al., (2020)].

WSN is the technology that has influenced most of the applications of automation, and monitoring. This tremendous success of WSN in a variety of applications is due to its easy implementation, low cost, and freedom from laying physical wires and cables. It has made communication technology reach a pinnacle where it couldn't spread in the past. Micro-mechanical devices are the backbones of a WSN. A typical WSN has a huge amount of small-sized sensor nodes that can self-configure themselves to communicate wirelessly with each other or with the sink nodes. Usually, they are deployed in together to monitor either all points in the area of attention, discrete targets, or intruders coming into the network. In a WSN, energy consumption is one of the considerable things. The energy is consumed when the node either transmits or receives data [Ji W et al., (2021)]. The simple energy consumption process is exposed in below Fig. 1.

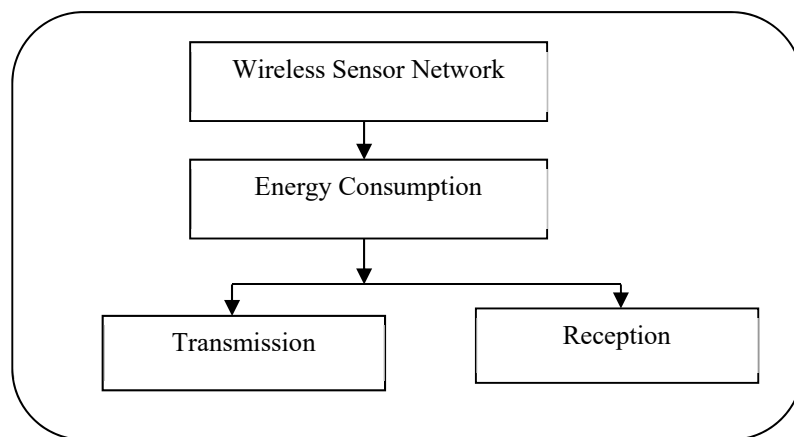


Fig. 1. Energy consumption in WSN

The collected data is moved on to the BS in two ways as single-hop or multi-hop. In single transmission, every CH transmits data directly to BS. As a result, the CH far off from BS will be depleted of energy faster creating energy unbalance in the network [Ruan D et al., (2019)]. Whereas in Multi-hop transmission, every CH transmits data to the nearby CH until it reaches BS. The accumulated data is forwarded by the CHs nearest to BS. As a result, the CH nearby to the BS gets energy depleted. This process paralyzes the entire network architecture though most of the nodes still hold energy in it. This is an energy-hole problem. This problem can be eliminated by proper node implementation, load balancing, and allocation. Several Optimization algorithms are implemented in WSN technology [János S et al., (2011)]. WSN optimization challenges have been solved using biologically inspired algorithms. Clustering concerns such as node deployment, CH selection, the ideal number of CHs, localization, and data aggregation have been addressed using heuristic and meta-heuristic methodologies. WSN nodes lose

energy due to incorrect sensor placement, ineffective data aggregation, inefficient routing methods, and insecure data transmissions, among other factors. The WSN's performance is affected by many factors, including the nodes' location, connectivity, coverage, power consumption, lifespan, and reliability, among others. Due to technological improvements, the sensor's role grows [Fadel E et al., (2015)].

2. Literature survey

This chapter covers the Wireless Sensor Networks (WSN), the various technologies used in this research work, and a literature survey on the existing background work in this field. This is followed by a premiere on various strategies adopted for minimizing the energy consumption in WSNs, like the clustering strategy. [Shankar Kartik J et al., (2013)] proposed the new scheduling algorithms in μ C / OS-II RTOS method with its hardware accomplishment. The new scheduling algorithm acts as a breakthrough with limited tasks, and hardware, maintaining the correctness of the software scheduler and improving the efficiency of the entire real-time system. A new scheduling algorithm was used to modify the original μ C/OS-II algorithm by adding comparison at a similar precedence stage [Muruganandham, S.K et al., (2018)]. LDA algorithm with readily available data when comparing fuzzy logic algorithms to current data packets, the results showed that delay could be reduced from main sources to destinations. In other situations, the life of a wireless sensor network is shortening as soon as the battery power in critical nodes runs out. As a result, the affordability of power is the most significant factor for architects and engineers of services and algorithms for WSNs, since the power consumption is regarded as the network capacity life of sensing devices.

[Shweta and Dinesh Rotake, (2014)] implemented an EDF algorithm that assures that all deadlines are met and that the total CPU usage is low is not more than 100%. μ C/OS-II RTOS utilized in this method for program part protection device is a real-time multi-tasking system. and the development method is analyzed in a real-time procedure scheme. CPU loading is measured by processor utilization. Trying to improve CPU loading is tricky since form-fitting must complete tasks over a certain amount of time. Even though μ c/os-II does not support a rate monotonic algorithm, it can be implemented by proper hardware re-design using high-end development boards [Wei Jiang et al., (2016)] presented a study on Ratio monotonic evaluation, which aids in achieving optimal CPU loading for various real-time tasks with time constraints. Prioritized preemptive scheduling is quick since it deals with the interruption as soon as it occurs. However, it takes more CPU cycles, resulting in lower process utilization.

Energy optimization was accomplished via the I coverage area [Sun, Z et al., (2011)]. Which refers to how a sensor network observes its area of interest, (ii) ideal positioning of numerous base stations to circumvent bottlenecks in separate base stations, and an agglomeration scheme that is entirely operated by the base station. (iii) The main goal of optimum scheduling is to solve the problem of sending a packet from one node or another over a point-to-point link in a specified amount of time. (iv) Trying to solve the dead-end issue that results in a high packet drop to the base station.

[Bharat Kulkarni, (2012)] the efficiency of network lifetime adds information on the life of all nodes within the network and then how long it will run, but it does not specifically identify a set of route features as a problematic restriction. In practice, there are several multiple routing options available for an estimated lifetime. As a result, there is a difficulty of more nodules in wireless communication as well as the surrounding circumstances. In several situations, it's also difficult, if not impractical, to replace or refuel the sensors' operating batteries. EEHC (Energy-Efficient Heterogonous Clustered) protocol for a tri-level network is proposed by [Kumar D et al., (2009)] to take advantage of node energy heterogeneity in WSNs. Sensor nodes' residual energy is used as a probability threshold function to select a cluster head. To improve network lifetime, EEHC outperforms LEACH as a heterogeneous method. It's also worth noting that in order to improve the stability interval, Author [Kumar D et al., (2009)] devised and presented an energy paradigm and traffic and energy-aware routing (TEAR), which assumes sensor nodes with variable initial energies and differences in traffic origination rates.

3. Proposed model

To ensure WSN nodes still have current and making progress toward that goal, we place requirements on the current and total counts, intending to balance energy use across all domains. This would cause a large reduction in electrical demand and lengthen the network's energy and lifespan lengthen the network's lifespan. Our suggested concept of energy shared should assist consumers in reducing their chances of experiencing an energy blackout. The consumers of mobile energy photo sharing are subjected to a comprehensive performance monitoring and optimizing framework. The paradigm is made up of two elements. The first element is based on optimization to assess the best energy sharing policy between users who are matched. In this proposed technique a Gravitational Search Algorithm (GSA) to improve energy efficiency and network lifetime. For how long the sensor network has been operational, this metric is displayed. It all boils down to what the ultimate goal of this network is. When the first sensor dies, the network's service life can be measured in terms of the percentage of sensors that die or coverage is lost. Half of the active nodes are included in the performance measures used to evaluate network life.

The simulation results show that the sum of clusters in a network reduces as the number of SNs in a cluster increases for a fixed network length. This, in turn, will increase the SN's power consumption, which will shorten the network's life span. Data transmission, processing, and reception using all of the nodes' available power. In a cluster, as the number of nodes grows, so does the amount of energy used for transmission.

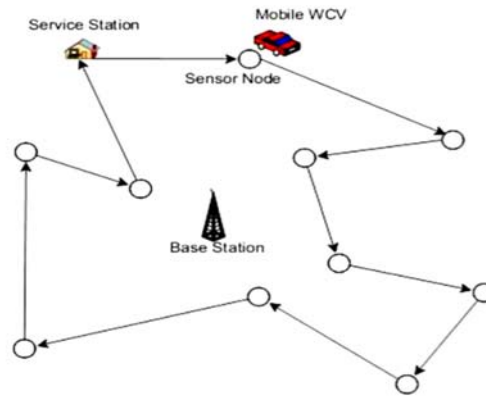


Fig. 2. System Model

Solutions that can be used with different network configurations and yet meet the sustainability criterion. Our system consists of a mobile charger (WCV). Table 1. depicts the parameters considered for the simulation.

Parameters	Value in Units
Amount of sensor nodes	50
Energy ingesting for sensor nodes	10–20 J/min
Charging rate of the sensor	6 J/min
The sensor nodes Battery capacity	10,000 J
Charging of the sensor	20 J/min

Table 1. Simulation parameter

3.1. Gravitational Search Algorithm (GSA)

GSA is based on Newton's second law of motion and the laws of gravity and mass interaction. According to the law of gravity, which states that acceleration is relative to R^2 , each particle in GSA accelerates its velocity inversely proportionate to R . Both methods were found to be more effective than the other, according to the researchers [Rashedi E et al., (2009)].

However, unlike CFO, the stochastic GSA concept and formulation are very similar. The position of all the other masses affects the position of the particles. Position, inertial mass, active mass, and passive gravitational mass are all characteristics of mass. Its masses are calculated using a predefined fitness function based on the mass of the mass in question. Figure 3 shows the impact of particles.

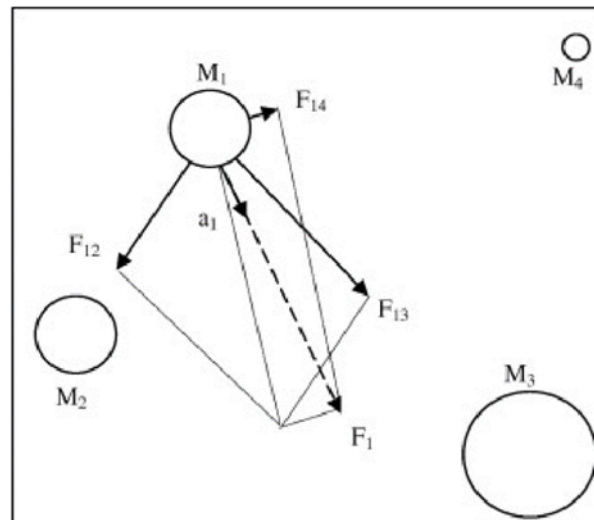


Fig. 3. The effect of the particle on additional particles.

Initialization, fitness evaluation, gravitational constant control, updating inertial and gravitational masses, updating force, acceleration, and velocities, informing particle positions, and finally determining whether or not termination criteria are met are the eight primary steps in the GSA process [Shukla A et al., (2016)].

Algorithm 1. Algorithm for GSA

```

Input :  $L_{sort}$  – a list of candidate solutions arranged in descending
order of its fitness value
Output:  $S$  – a record of best fitness value identified optima
begin
  if  $S = \emptyset$  then
    While not reaching the  $eL_{sort}$  do
      If best unprocessed  $X_b \in L_{sort}$ 
         $S \leftarrow S \cup \{X_b\}; \rho \leftarrow f(X_b);$ 
      end
      else
        if  $f(X_b) > \rho$  then
           $\rho \leftarrow f(X_b); update \leftarrow True;$ 
        end
        if  $update$  or  $|f(X_b) - \rho| < \epsilon$  then
          foreach  $X_s \in S$  do
            if  $\|X_b - X_s\| \leq r$  then
              if  $f(X_b) > f(X_s)$  then
                 $p \leftarrow s;$ 
                 $found \leftarrow True;$ 
                break;
              end
            else
               $Foundtrue;$ 
              break;
            end
          end
          if not found then
             $S \leftarrow S \cup \{X_b\};$ 
          end
        end
      end
  end

```

3.1.1. Presentation Criteria

Peak Ratio (PR) and Success Rate (SR) are two performance indicators used to gauge the method's effectiveness. As a result, it is necessary to have a set maximum number of function evaluations (MaxFE's) to evaluate an niching technique throughout numerous runs.

3.1.2. Peak Ratio

Over numerous runs, Peak Ratio (PR) is used to measure the average proportion of all known global optima. An analogy would be to think of it this way:

$$PR = \frac{\text{No.of global optima found in the end of iteration } i}{\text{No.of known global optima} \times \text{Number of Run}} \quad (1)$$

3.1.3. Success Rate

It is the percentage of all known global optimums that are found in a given run. Thus, the success rate (SR) is a measure of the percentage of successful runs. An analogy would be to think of it this way:

$$SR = \frac{\text{No.of Successful runs}}{\text{No.of runs}} \quad (2)$$

3.1.4. Convergence Speed

A niching algorithm's convergence speed is determined by counting the number of function evaluations required to identify all recognized global optima at a certain accuracy level of 0.1. Over numerous runs, we can calculate the average function evaluations (AFEs):

$$AFEs = \frac{\text{No.of evaluations used in } i\text{th run}}{\text{Number of runs}} \quad (3)$$

Using the maximum function evaluations (MaxFE's) is used to calculate function evaluations if the method is unable to locate all global optima.

4. Results and discussion

MATLAB is used to evaluate the presentation of the scheme. A 100-SN linear network is simulated. Between (x=0 and y=0) and (x=1000 and y=10), the SN are evenly scattered over a distance of 1000 m. It is presumed that the network is homogeneous. The SN, the cluster heads, and the sink nodes are all fixed positions. (x=500, y=5) is the location of the BS. Assumed that all nodes are positioned equally and linearly throughout the network. There is a finite number of SN in the universe. Infinite energy and charging resources are available at the base station sink node. When it comes to modeling, a free space model is a viable option. The half-life of the network is distinct from the time up to which half of the nodes are operational. In the proposed work, the results are taken in the NS2 simulator. The energy efficiency of the network is improved when using GSA for finding the travel path for the WSN. Sensor nodes are deployed over a 100×100 m² area.

Scaling Factor	Score parameter	Score
Current energy level	Below threshold	2
	Above threshold	1
	Initial level	0
Energy supply through harvesting devices	Low	2
	Moderate	1
	High	0
Frequent of sensing	Low	0
	Moderate	1
	High	2

Table 2. Scaling factors.

4.1. Constraints for mass conservation

At every node, the conservation constraint for mass must be satisfied;

$$\sum Q_{in} - \sum Q_{out} = Q_c \quad (4)$$

Where Q_{in} = rate of flow into the node, Q_{out} = rate of flow out of the node, Q_c = rate of external inflow at the node.

4.2. Constraints for energy conservation

In every loop present in the WDN, the constraints for conserving energy are given as;

$$\sum \Delta H_k = 0, \forall l \in NL, k \in loop \quad (5)$$

Where ΔH_k = loss in water head in pipe k, NL = number of loops present in the system.

4.3. Network lifetime Comparison

How long the WSN has been running at full capacity is indicated by Network Life. A network's life span is determined by the maximum number of rounds to death of 50% of the nodes in the network for clusters of different sizes, as outlined in this study. Table 2 shows that when the total quantity of nodes in a cluster increase, the network life shortens. Each node's energy level is determined by its battery capacity. If a node's battery level falls below the threshold, it must be instantly charged.

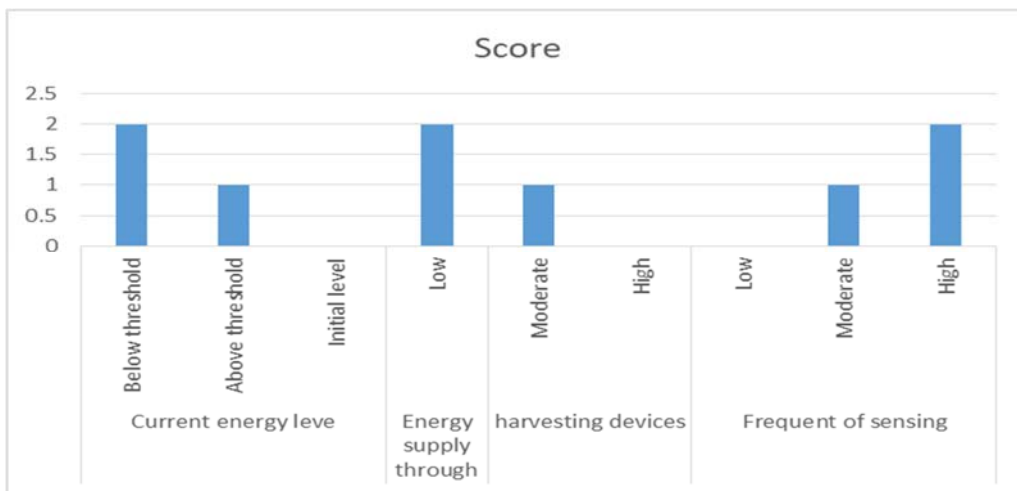


Fig. 4. Graphical representation of scaling factors

Iteration	No. of alive nodes	
	ABC	GSA
1	24	25
2	18	19
3	17	18
4	16	17
5	14	16

Table 3. Number of alive nodes.

Table 4 compares the sum of active nodes during the course of the network's operation utilizing various protocols. They are analyzing the performance algorithms. In order to track changes in energy usage, the model is run repeatedly over time. The sum of nodes alive is also improved when the harmony search algorithm is utilized.

Iteration	Energy Consumption in milli joules	
	ABC	GSA
1	104	89
2	95	82
3	90	79
4	88	76
5	80	71

Table 4. Energy Consumptions.

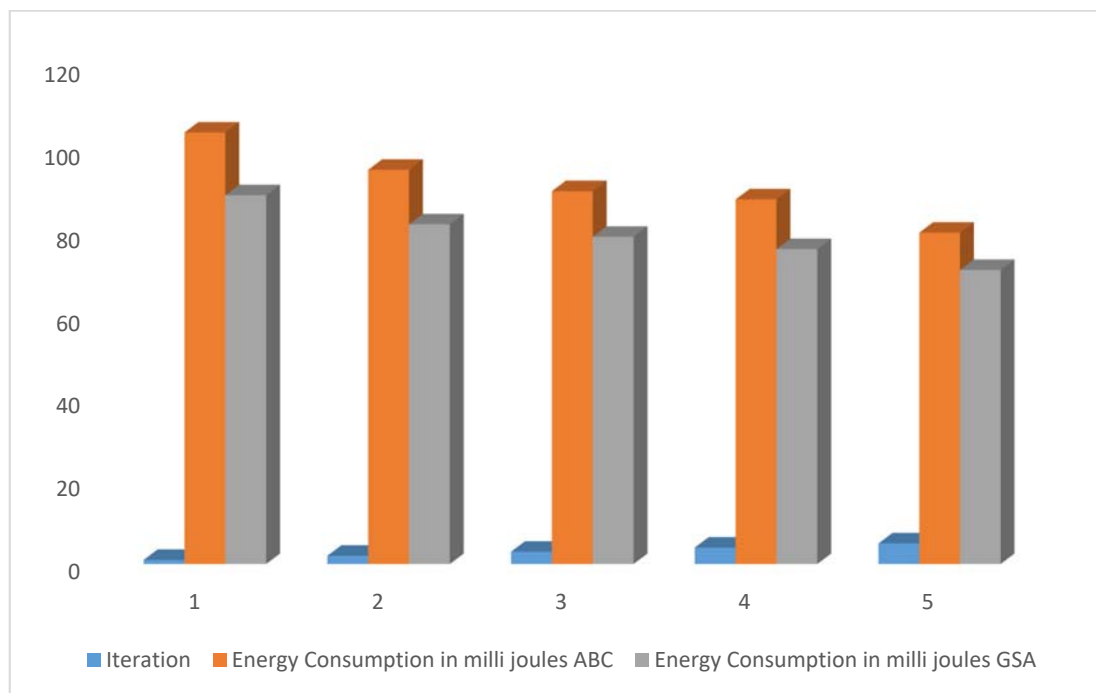


Fig. 5. Graphical representation of Number of alive nodes

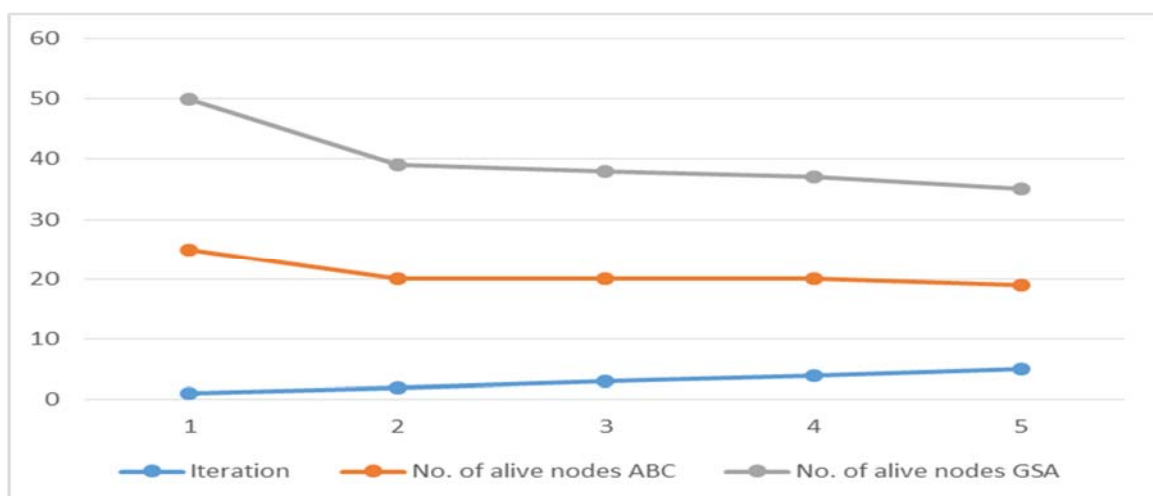


Fig. 6. Graphical representation of Energy Consumption in millijoules

When the sum of rounds is augmented then the number of nodes alive is also increased. The overall energy consumption in the network during data transmission between the sensor nodes is shown in Figure 6. Energy consumption includes energy for transmission and reception, and the minimum voltage supply required for operation, in the proposed algorithm the energy consumption of the network is reduced for the later iterations.

Iteration	Energy in millijoules	
	ABC	GSA
1	3	4
2	5	8
3	8	10
4	10	12
5	12	16

Table 5. Comparisons of Energy Consumption

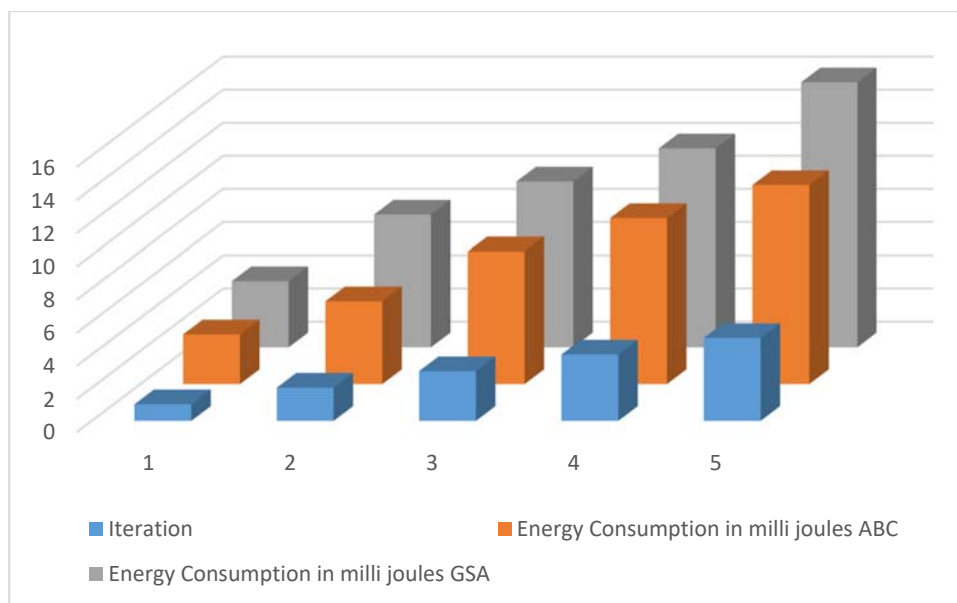


Fig. 7. T Graphical representation of a comparison of Energy Consumption in millijoules

The number of nodes to be dead is rescued by transferring energy from it to sensor nodes. Figure 7 shows that the numbers of nodes rescued are high in the GSA algorithm.

5. Conclusion and Future Work

For heterogeneous and homogeneous wireless sensor networks, this research proposes energy-efficient and QoS architecture. Additionally, the suggested hybrid approach improves energy efficiency and network life span. The nodes in a cluster, the amount of times a node has been the cluster leader, and the number of nearby nodes are all included in a fitness function. Data transmission and receiving within the sensors overcome the sensors' energy consumption. Splitting the network into short linear parts is advocated here to lessen the cluster's energy consumption. The results of our simulations reveal that our approach significantly increases network longevity and minimizes energy dissipation. Strip-based wireless sensor networks can be used for research by introducing higher-energy nodes and mobile sinks. With this, the nodes may more efficiently regulate their communication range, resulting in even greater savings in power usage. These efforts are aimed at keeping the network's energy supply intact by extending the life of sensors.

6. Conflicts of Interest

The authors declare no conflict of interest.

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