# Enhanced Lifetime with Less Energy Consumption in WSN Using a Genetic Algorithm-Based Approach

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# ENHANCED LIFETIME WITH LESS ENERGY CONSUMPTION IN WSN USING A GENETIC ALGORITHM-BASED APPROACH

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*Abstract*—**Enhanced lifetime means to increase or improve the value, quantity, desirability, or attractiveness. Energy efficiency simply refers to using less energy to complete the same task, thereby reducing energy waste. Energy efficiency protocols are used in wireless sensor networks to improve system energy conservation and lifespan. In a WSN, instead of using physical media for communication, transmission is accomplished through the deployment of nodes. The deployed nodes send data to the destination node or to the sink node. The process of gathering the nodes for improved communication is referred to as clustering. During clustering, neighboring nodes that are part of a compatible cluster send data to the cluster head, aggregating it and sending it to the sink.**

**For the enhancement of WSN, many clustering algorithms have been created. In the case of the traditional approach, the node prefers a straight-line path hence it consumes more energy a reduction the lifetime. Hence, another genetic algorithm-based approach is VGDRA. Since the proposed method is dynamic rather than static, it has a higher energy efficiency than LEACH, because it takes the shortest path. Balanced load and optimization increase the likelihood of better results in lower loops, which other techniques cannot achieve. The proposed method's simulation results are generated using MATLAB R2022 b.**

**Keywords—WSN; Energy efficiency; genetics.**

## I. INTRODUCTION

The term "Wireless Sensor Network" (WSN) refers to an ad hoc wireless network that detects system, physical, or environmental factors using many wire-free sensors. WSN uses sensor nodes with built-in CPUs to control and track the environment of a specific area. They are linked to the Base Station, which serves as the WSN System's computational hub. A WSN system's base station links to the web in order to share data. Deployment has garnered a lot of attention in recent years as a study area since it is a basic problem with WSNs. The network's topology, which in turn affects many of its inherent qualities, including coverage, connectivity, cost, and lifetime, is determined by the quantity and position of sensing devices implemented in an RoI. As a result, the deployment of a WSN greatly influences its performance. Both data router and data originator behaviour could be displayed by a sensor node. The data from sensors is gathered by a sink, on the other hand. As an illustration, in an application that monitors events, Sensors must communicate information to the sink (s) whenever they notice the occurrence of important events. The end-user and the sink may communicate with each other directly or by satellite, the Internet, direct wireless connections, or any other means. The possibility of various end users and sinks should be noted.

### *1.1. Components in the WSN system:*

**Sensors:** In a WSN network, sensors are tools that take measurements of physical characteristics like temperature, humidity, pressure, or motion. Electrical signals are created from sensor signals and wirelessly transmit the information.
**Gateway or base station:** A gateway, also known as a base station, is a central node. collects sensor data and sends it to a server or cloud computing platform.
**Network node:** Intermediary nodes that serve as a node conduit between sensors and gateways in wireless communication networks.
**Dead Node:** The nodes which have zero energy or lost their complete energy. A dead node refers to a network node, such as a computer, server, or network device, that is no longer operational or is unable to communicate with other nodes on the network. A dead node can be caused by a variety of factors, such as hardware failure, software issues, network configuration problems, or network connectivity issues.

When a node becomes dead, it can disrupt the functioning of the network by preventing other nodes from communicating with it. This can lead to network congestion, slowdowns, and potential data loss or corruption. In some cases, a dead node may also pose a security risk by allowing unauthorized access to the network.
**Power Source:** A power source is a device or system that provides electrical energy to power electrical devices or systems. Energy harvesting modules, solar cells, or batteries serve as the sensors and nodes' power sources.
**Evaluation Software**: The evaluation software processes the data received to assess or measure the performance, effectiveness, or quality of other software programs or systems. Evaluation software can be used in a variety of contexts, such as in software development, software testing, quality assurance, or performance analysis.

Evaluation software can take various forms, including test automation tools, load testing tools, debugging tools, code analysis tools, and monitoring tools. These tools can be used to measure different aspects of software performance, such as response time, scalability, reliability, security, and user experience.

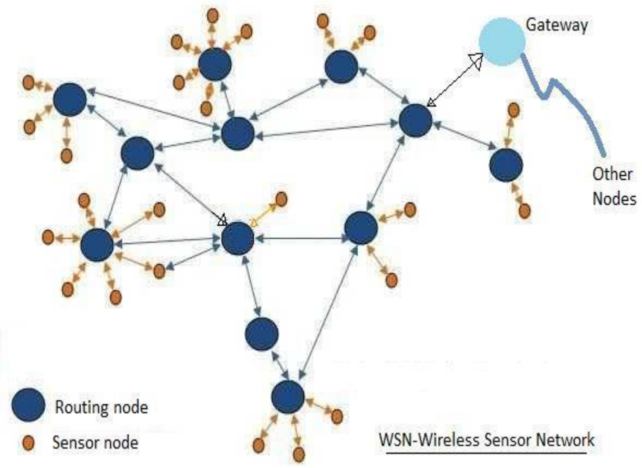


Fig:1.1 Wireless sensor network

## II. RELATED WORK

In the paper [1], The suggested mechanism makes adaptive adjustments to the sensor nodes' transmission ranges and the sink relocation plan using data on the remaining battery energy of the sensor nodes. Given are some theoretical and numerical analyses that demonstrate how considerably the EASR approach can increase the network lifetime of the WSN. In a WSN, sensor nodes multi-hopping to send sensed data back to the sink. The effective network lifetime extension technique of sink relocation prevents a particular sensor node group from using excessive amounts of battery power. In this study, we provide an EASR technique for movable sinks in WSNs.

In the paper [2], In this research, a unique method for periodic data gathering from WSNs is proposed. It is named VGDRA. The proposed method does not impose any such restrictions, in contrast to existing alternatives that increase data transmission performance by employing a number of mobile BS or by strategically positioning active nodes in the sensor field. It adheres to the WSN's low-cost concept and attempts to maximize the transfer between node energy usage and data transmission performance using a single mobile sink.

In the paper [3], Due to its dynamic approach and load balancing, the suggested method uses less energy than LEACH. When compared to other strategies, optimization techniques are more compatible with finding better results with fewer loops. The network's lifespan is influenced by node energy efficiency to some extent. The GA with VGDRA algorithm is designed to extend the network lifetime while consuming less energy. We looked at the suggested method in two scenarios with varying node counts and geographic areas. In each case, we were able to provide effective energy with a long lifetime.

In the paper [4], In this study, we present an energy-efficient protocol to reduce sensor node power consumption and improve the sink node's data accuracy in event-driven wireless sensor networks. Each sensor node in our algorithm has several boundaries and a versatile sampling frequency is used to conserve energy when no events occur and to rapidly wake up the appropriate sensor nodes when an event occurs. To lessen the effect of retransmission and ACKs, each packet receives some information, such as the next packet's forecast. The weaker sensor nodes transfer tasks to the stronger sink node. We plan to put these algorithms to the test in a variety of scenarios and use machine-learning techniques to change parameters like sensor thresholds.

The paper [5], This paper provides an overview of the most common hierarchical network architectures for WSNs. It conducts a detailed analysis of various topologies for atypical hierarchical WSN routing. It looks at some representative atypical hierarchical routing protocols and their characteristics, benefits, and drawbacks. In terms of performance and application scenarios, various atypical cluster-based routing protocols are compared.

In the paper [6], A new routing strategy based on a genetic algorithm is proposed in this Proposed Model to identify an appropriate path for a sensor node to send information to the BS. Both theoretically and empirically, GA has been demonstrated to be a reliable search technique. Each GA member suggests a possible fix for the issue. Furthermore, each is linked to a fitness function in the population's next generation, based on Darwin's survival of the fittest principle. The routing suggested algorithm specifically seeks to ensure that each sensor node finds a viable path to the base station to send data. This led us to suggest a clustering technique in which CH is selected based on a fitness function.

The paper [7], This paper discusses and proposes methods for planning an arbitrary WSN. To that end, we propose another network architecture based on realistic circumstances in which nodes powered by renewable energy sources (called primary nodes) handle many message delivery tasks and nodes powered by traditional chemical batteries (called secondary nodes) handle the rest.

In the paper [8], To compare lifetime, energy consumption, and the maximum number of hops, various optimization techniques such as (PSO), (GSA), and Least Distance Clustering are used (LDC). This paper proposes a method for extending the lifetime of WSN networks. For clustering, optimization algorithms were applied to each cluster separately. Using this method, cluster member nodes save energy while transmitting sensed data to the cluster head. As a result, each cluster member node's lifetime increases. On cluster heads deployed across the entire routing area, optimization techniques have been used.

In the paper [9], The optimization goal is to maximize the lifespan of the first and a half of the nodes. Finally, both before and after improvement, the prefabricated substation is subjected to the LEACH protocol. Sensor nodes collect operational parameters for equipment as well as environmental parameters for the substation. Data is transmitted using the

LEACH-H and LEACH protocols. Hence from the simulation results, the LEACH-H protocol outlasts the original LEACH protocol and improves network performance.

## III. PROBLEM FORMULATION:

Topology management is seen as a feasible way for guaranteeing the stability, dependability, reliability, and efficiency of network infrastructures like WSNs. Clustering is a widely known method for managing WSN topologies. A clustering strategy puts nodes into clusters according to specified criteria such as maintaining Quality of Service (QoS), optimizing resource use, and balancing network load. Each cluster contains one or more Cluster Heads (CHs) who gather data from cluster members and deliver the data to BS be it directly or indirectly via other nodes known as intermediary nodes. Resource-constrained nodes are not needed to deliver data directly to sinks when using grouping techniques, which can lead to energy depletion, wasteful resource utilization, and interference. WSN clustering approaches have been described in several research articles. Nevertheless, many of them simply address basic clustering techniques like LEACH, HEED, and FLOC, which are suggested in various forms as well as expansions. Some survey articles use only one measure to develop clustering algorithms or network architectures such as uneven clusters. Numerous additional survey investigations have also investigated approaches that deviate from the basic strategies. There are approximately 60 expanded variants of just the LEACH protocol in literature, according to the authors. Additionally, clustering has been researched from the aspect of minimizing energy usage in certain survey reports, even if this is not the sole cause for grouping. To summarize, most grouping survey studies investigate and evaluate clustering approaches and their effectiveness without comparing the techniques' motives. Additionally, survey studies have examined existing clustering 3 approaches in terms of WSN network aspects that they enable, along with heterogeneity and mobility.

This encouraged us to perform a thorough investigation of clustering aims in WSNs. This work investigates WSN-based grouping strategies in terms of clustering goals such as QoS, load balancing, fault tolerance, and so on. We also evaluate the approaches' compatibility using various network parameters such as heterogeneity & mobility. Lastly, we look at the future of clustering research and provide a statistical approach to encourage scientists to employ clustering to solve network management problems. This survey also allows for the discovery and assessment of clustering algorithms that support a certain set of goals.

### *3.1. Main operational stages in WSN:*

1) NODE PLACEMENT
2) NETWORK COVERAGE
3) CLUSTERING
4) DATA AGGREGATION
5) ROUTING.

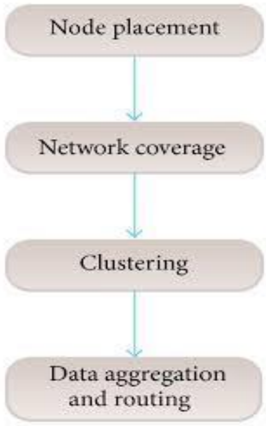


Fig:3.1 Operational stages

**NODE PLACEMENT**:

Node placement optimization is commonly used for existing node placement and can adjust where the node is required. Nodes in some harsh environmental sensors can only be placed randomly. Thereafter, the node placement optimization technique should find a node positioning that matches the application criteria, and with it, the node should move to a suitable place. When constructing a WSN or a HEWSN, the first step is node placement. A well-placed node can reduce consumption and extend the life of a WSN while still providing adequate coverage. Sensor nodes in HEWSN have a variety of functions, sensing types, mobility, and parameters. Many other academics have provided acceptable node placement strategies as well as node positioning optimization techniques for certain HEWSNs. This research focuses on HEWSNs with different sensing kinds with identical parameters. Another word for it is hardware heterogeneity. One of the key issues that WSNs encounter, when confronted with hardware heterogeneity, is prolonging WSN lifespan. Neighbors are nodes that are aligned toward the selected node for transferring data. They are neighbours in the network topology. This is mostly for coverage purposes. If the traveling distance is small, the coverage hole may be nearly filled. As a result, the neighbour nodes presented in this section are space-distance neighbours rather than networked topology neighbours. Nodes with coordinates close to the selected node are considered neighbour nodes. If a node's coordinate is, a node that satisfies is one of the node's neighbours.

**NETWORK COVERAGE**:

The goal of the node positioning optimization challenge is to optimize sensor node placement and network topologies such that the network can fulfill all the target area's application and coverage criteria. The basic components of a WSN is the sensor nodes, which gather information and deliver it to a receiving device for further processing. Additionally, understanding how to install individual sensors in a network such that they cover the maximum possible area is crucial. Different strategies for node deployment are used in a network to ensure efficient deployment. The concern when nodes are installed is whether they capture all the details in that location; this is based on coverage or how accurately a node detects a certain region. This article provides a concise overview of WSN deployment as well as coverage. The various optimization algorithms employed in WSN deployment are also discussed. An evaluation of several deployment strategies is shown, according to how they perform and the region in which they've been deployed.

**CLUSTERING**:

Clustering refers to the action of grouping populations or data points so that data points belonging to the same group are more like one another. The WSN clustering algorithms are executed in the centralized Bs, which contains all the node location details in the network. Genetic operations are applied to random initial populations until the termination conditions are met. The WSN is made up of nodes ranging in size from a few to hundreds or even thousands, with each node connected to other sensors. Clustering is a potential method for prolonging network lifespan in wireless sensor networks (WSNs). A sensor is a small electronic device that detects and processes data before sending it to a base station. It is used to measure changes in physical environmental parameters such as temperature, pressure, humidity, and sound, as well as changes in people's health parameters such as heartbeat and blood pressure. A sensor node should be small, consume very little energy, operate autonomously, and have a very low power consumption.

**DATA AGGREGATION**:

The action of acquiring and integrating meaningful information in each subject of interest is known as data aggregation. The effectiveness of communication among nodes is determined by the data aggregation techniques used. The main operation flow of GA comprises constructing an initial population, evaluating fitness, crossover, selection, mutation, and choosing a cluster head that can reduce the Peak intra-cluster distance between the network and its cluster member by decreasing the network's power usage. WSN is a rapidly growing area in a variety of domains, including operations, military applications, and health applications, among others. Data aggregation is a vital strategy for eliminating duplicate information from acquired data, making it possible for us to greatly reduce individual nodes' energy usage. This decrease contributes to WSNs having a longer lifespan. In this study, we sought to offer an overview of several available techniques in the literature. We have tried to develop a list of all existing data aggregation techniques based on several performance parameters including energy consumption, network lifetime, latency, cost of energy, and so on. Lastly, this article provides guidance to the reader in selecting the optimum data aggregation technique for the application. The process of obtaining data from the network's source node is referred to as data gathering. Transferring the acquired data to the sink node wastes bandwidth since it includes redundant information. It also raises the energy usage of the nodes. As a result, node energy usage must be reduced by lowering the number of packets delivered, hence increasing network lifespan. The primary goal of this is to decrease redundant data by extracting valuable information from obtained data and transferring it to the sink using data aggregation algorithms like MAX, MIN, MEAN, MEDIAN, and so on.

**ROUTING**:

Routing is said to be the process of determining the best path from a source node to a destination address and the network minimizes routing node energy usage. The distance constraints between various sorts of network nodes are then studied. The distance between the transmitting and receiving nodes in relation to the base station is one of these characteristics. Efficiency: Low overhead. The genetic algorithm is being utilized to tackle an issue with a network routing system. The method must find the shortest path between starting and ending nodes. In the literature, the routing problem is tackled by employing search graph algorithms to identify the shortest path. Dijkstra's algorithm is a prominent solution to this problem. To solve the routing problem, the proposed genetic algorithm is contrasted against Dijkstra's method. MATLAB is used to generate simulation results for both algorithms. The findings validated the proposed genetic algorithm's potential.

## IV. Methodology:

A genetic algorithm is a heuristic optimization method inspired by the process of natural selection and genetics. It is a computational technique that uses a population of candidate solutions (often represented as chromosomes or strings of bits) and applies genetic operators such as selection, crossover, and mutation to evolve new candidate solutions that are potentially better than their predecessors.

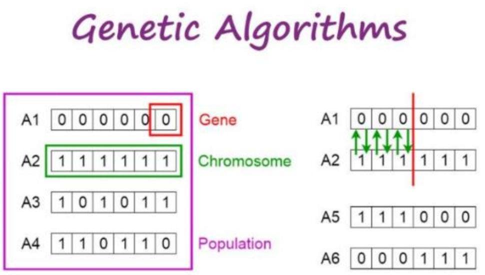


Fig: 3.1 Genetic Algorithm

The basic idea of a genetic algorithm is to start with a population of randomly generated solutions, evaluate their fitness based on a specific objective function, and then apply genetic operators to create a new population of solutions that are slightly different from the previous population. The process is repeated for many generations, with the hope that the fitness of the best solutions will improve over time.

**A genetic algorithm considers five phases:**

1. Initial population
2. Selection
3. Cross-over
4. Mutation
5. Termination

**INITIAL POPULATION:**

In this phase, the initial population of candidate solutions is generated randomly. The size of the population is typically determined based on the complexity of the problem and the computational resources available.

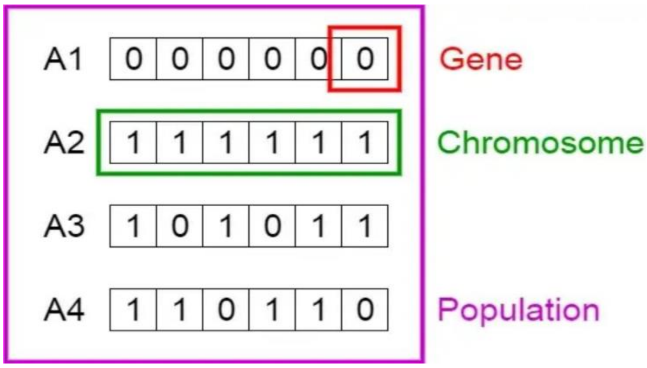


Fig:3.2 Initial population

**SELECTION:**

In this phase, a selection process is applied to the population to identify the fittest individuals (i.e., those with the highest fitness values). The selection process is typically based on a fitness function that evaluates each individual's performance on the problem being solved.

**CROSSOVER:**

In this phase, the fittest individuals are selected to mate and produce offspring. The crossover operation involves exchanging genetic information between two individuals to create new offspring that inherit some characteristics from each parent.

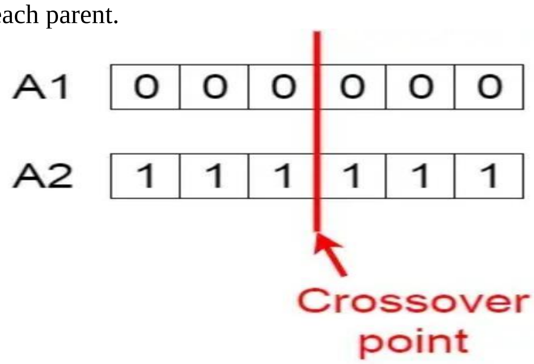


Fig:3.3 Cross over

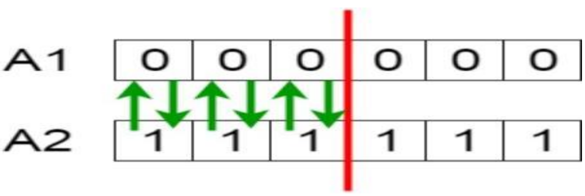


Fig: 3.4 Offsprings

**MUTATION:**

In this phase, a small percentage of the population is randomly mutated to introduce new genetic information. Mutation can be seen as a way to introduce diversity into the population and explore new regions of the search space.

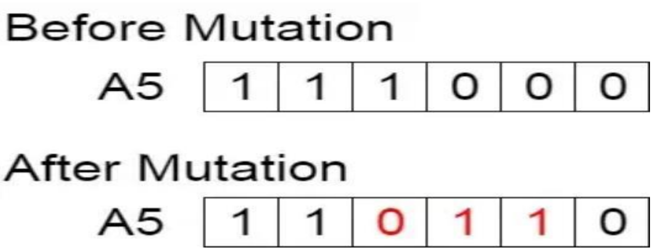


Fig: 3.5 Mutation

**TERMINATION**:

In this phase, the algorithm terminates when a stopping criterion is met. The stopping criterion can be based on various factors such as the number of generations, the fitness value of the best solution, or a predefined threshold. Once the algorithm terminates, the best solution found by the algorithm is returned as the final result.

***4.1 Software Used:***

MATLAB is a numeric programming language developed by MathWorks that is used in matrix laboratories. MATLAB is a high-level language with numerous toolboxes. MATLAB is a program that allows us to analyse data and perform modern and engineering calculations. We can develop an algorithm using MATLAB engineering and Scientists worldwide use MATLAB for application in industrial schools, and colleges, machine learning algorithms, and all examples of computational technologies. The term "electronic commerce" refers to the sale of electronic goods. The "command window" is the most used feature of the MATLAB application.


Fig:4.1 MATLAB R 2022 b

## V. PERFORMANCE EVALUATION

In this study, we evaluate the results using two cases to achieve the best results. The first case uses a genetic algorithm and the other case is comparing both the genetic algorithm and the LEACH-based approach. VGDRA is the successor to WSN for periodic data collection utilization. It entails optimizing the transfer between node energy consumption and information conveyance performance using a small digital sink while adhering to the WSN's minimal effort subject. This framework helps the sensor network to follow a nearly suitable path to a mobile sink's most recent location while incurring minimal network overhead. We increase the lifespan of sensor nodes by using a genetic algorithm to reduce their energy consumption. MATLAB is used to generate simulation results. The use of virtual grids allows for the equal division of area and nodes. It divides the total area into equal-sized horizontal and vertical blocks, and the nodes are distributed evenly across the region. It ensures that the network's load balance is maintained.

### *5.1 Genetic :*

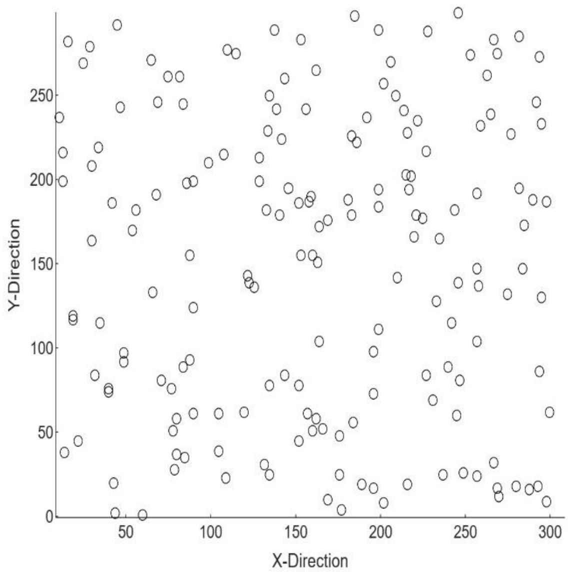


Fig: 5.1 Total number of nodes

The figure shows the network's grid layout model with the same set of nodes in each block. With the use of virtual grids, area, and nodes are divided equally. The nodes are distributed evenly throughout the entire area and the complete area is divided into blocks of equal size both horizontally and vertically.

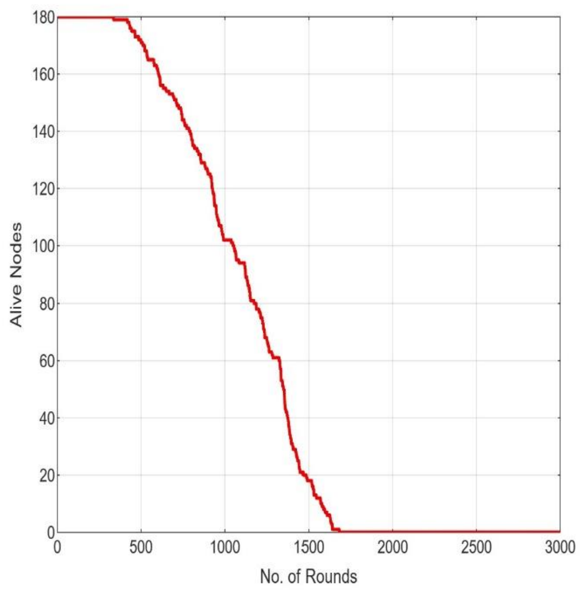


Fig: 5.2 Alive nodes

In the figure, we have considered up to 3000 rounds and 180 alive nodes, up to 700 rounds the number of dead nodes is equal to zero, and after that, it quickly increases. At about 1800 rounds, nodes have a value that is more than zero. It shows that using the suggested strategy, the first dead node lasted 700 rounds and the final dead node lasted 1800 rounds.

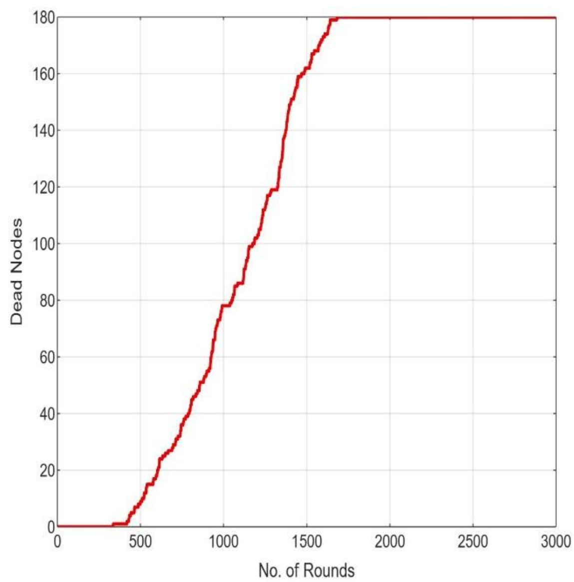


Fig: 5.3 Number of Dead nodes

In the figure, the suggested technique's maximum number of alive nodes occurs after 700 iterations with 180 nodes.

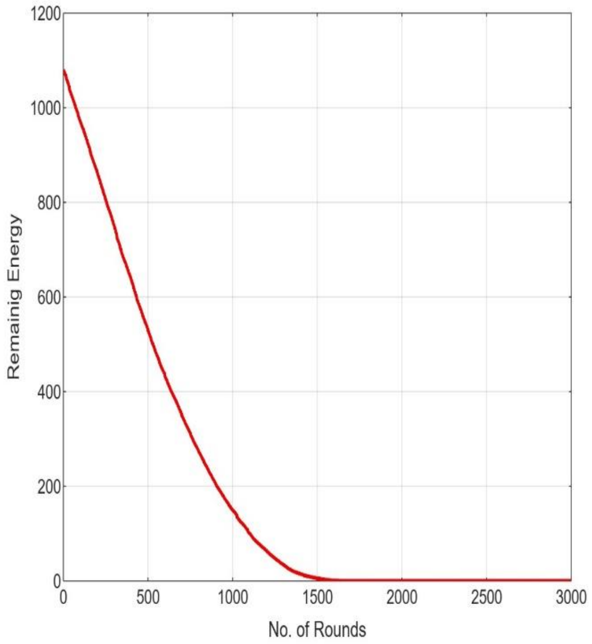


Fig: 5.4 Remaining energy

In the figure, the suggested algorithm significantly outperformed other algorithms in terms of residual energy performance, It is evident that the residual energy does not stabilize for a very long time. Most nodes have more energy overall because the data flow is maximized by using less transmission energy and only transmitting packets when the base station is physically closest to the cluster head.

### *5.2 Genetic Vs LEACH :*

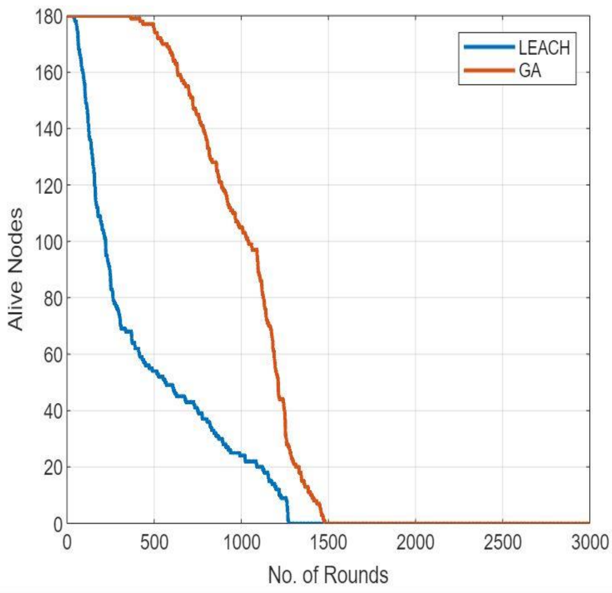


Fig: 5.2.1 Alive nodes vs No. of Rounds

In the Figure, the maximum count of alive nodes in LEACH occurs at 1200 rounds with 180 nodes, whereas the highest number of alive nodes in the proposed technique occurs at 1500 iterations with 180 nodes. It is clear that the number of alive nodes is greater in the proposed.

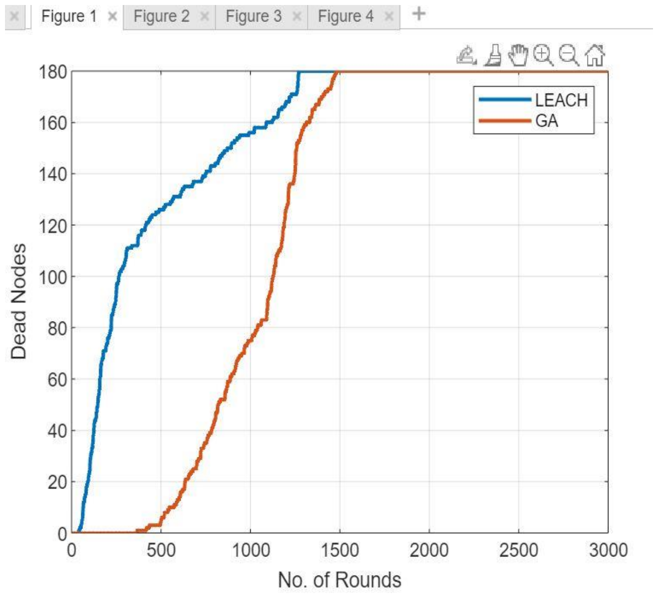


Fig: 5.2.2 Dead nodes vs No. of rounds

In the figure shown, the FND was reached in round 700, and the LND was reached after 1800 rounds and 1200 iterations with 180 nodes, as opposed to 900 rounds and 1200 iterations with 100 nodes for LEACH.

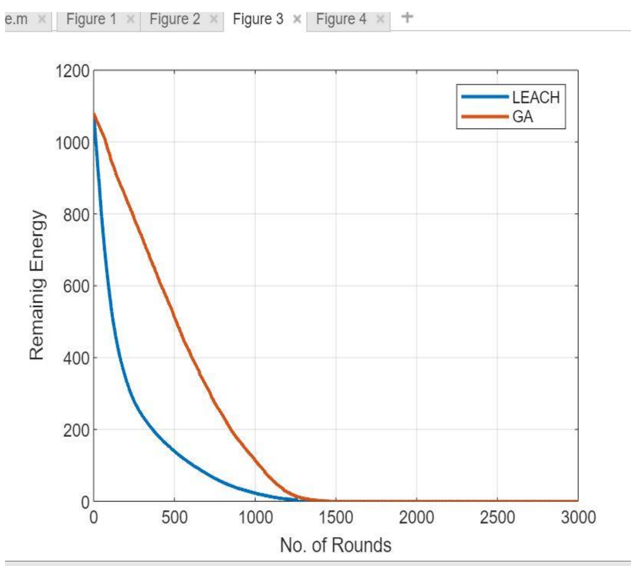


Fig:5.2.3 Remaining energy vs No of rounds

Fig. demonstrates the residual energy performance. It is clear that the leftover energy does not stabilize until much later. Since the data flow is maximized by using less transmission energy and only transmitting packets when the gateway(BS) is physically closest to the cluster head(CH), the majority of nodes are left with more energy overall.

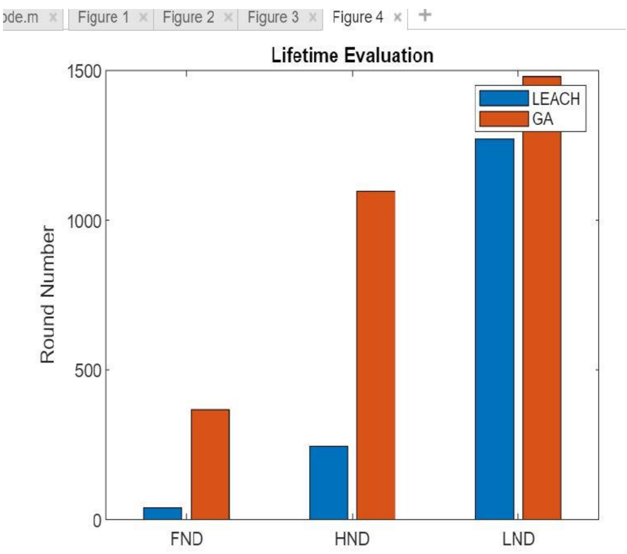


Fig: 5.2.4 Lifetime vs no of rounds

The LEACH, GA protocol's effectiveness has been measured in Fig. by the no.of dead nodes. In our simulation, there are 180 nodes. As can be seen from Fig., the time of the FND(first dead node) in the GA protocol is later than the LEACH procedure as the number of rounds increases. As a result of the GA protocol's constant attempt to choose an anode as CH that meets the aforementioned requirements, the energy consumption is spread among the nodes. No node will therefore be utilized beyond the scope of its capabilities, which in turn optimizes the network's overall energy consumption.

## VI. CONCLUSION

Numerous strategies and procedures have been developed to improve the efficiency and longevity of WSN networks. LEACH is the most often utilized approach. In our suggested solution, we developed a genetic algorithm-based approach that showed to be more energy-efficient than LEACH. We discovered that while using the genetic algorithm, more living nodes were present for the same number of Rounds as when using the LEACH method, increasing the network's efficiency.

We cluster the sensor nodes to improve scalability, robustness, and decreased network traffic. Nodes are randomly deployed across an area where monitoring is necessary and can be any number of them. The information acquired by the sensors is aggregated and delivered to the base station through battery-powered nodes, where a genetic algorithm optimizes the route to discover the quickest method to communicate the data. When fewer nodes are utilized, less battery is dissipated as compared to the standard technique. We utilized MATLAB simulation to see the outcomes of the two methods' comparisons using graphical representations.

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