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# GENETIC ALGORITHMS (GA) AND BACTERIAL CONJUGATION (BC) FOR DEVELOPING SOPHISTICATED CLUSTERING ALGORITHMS

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**Abstract -** Mobile wireless sensor networks (MWSNs) have emerged as a promising technology for various applications, including environmental monitoring, disaster management, and healthcare. However, the efficient clustering of sensors in Mobile wireless sensor networks (MWSNs) remains a challenging task due to the dynamic and heterogeneous nature of these networks. To address this challenge, researchers have explored the use of bio-inspired optimization techniques such as genetic algorithms (GA) and bacterial conjugation (BC) as clustering strategies. This article provides a comprehensive review of the use of Genetic algorithms (GA) and bacterial conjugation (BC) in clustering algorithms for mobile wireless sensor networks (MWSNs). Genetic algorithms (GA), an artificial intelligence based optimization technique, mimics natural selection and genetic evolution to find optimal solutions. Bacterial conjugation (BC), on the other hand, simulates the exchange of genetic material between bacteria to optimize the clustering process. Both techniques have been shown to be effective in addressing issues such as energy efficiency, load balancing, and network scalability in mobile wireless sensor networks (MWSNs). The article discusses the advantages and differences of these two techniques in the context of clustering algorithms for mobile wireless sensor networks (MWSNs). Genetic algorithms (GA)-based algorithms are suitable for optimizing multiple objectives simultaneously and provide a better trade-off between conflicting objectives. However, they are computationally expensive due to the large population size. BC-based algorithms, on the other hand, are less computationally expensive as they use a smaller population size. They are also distributed in nature and maintain network connectivity even when nodes fail. The article highlights the potential of combining Genetic algorithms (GA) and bacterial conjugation (BC) to develop more sophisticated clustering algorithms that efficiently handle the dynamic and heterogeneous nature of mobile wireless sensor networks (MWSNs). These algorithms could improve the overall performance of mobile wireless sensor networks (MWSNs) by addressing issues such as energy efficiency, load balancing, and fault tolerance.
**Keywords:** Genetic algorithm, bacterial conjugation, clustering, wireless sensor network, optimization, Mobile wireless sensor networks (MWSNs), cloud-based system, Sensor Cloud Model.

## 1 INTRODUCTION

### 1.1 Sensor Cloud Model

Sensor cloud is a model of a cloud-based system that collects, stores, and processes data from multiple sensors. Sensors are small devices that measure physical characteristics such as temperature, humidity, light, and motion. In a sensor cloud, these sensors are connected to the cloud through the internet, allowing data to be transmitted and analyzed in real-time.

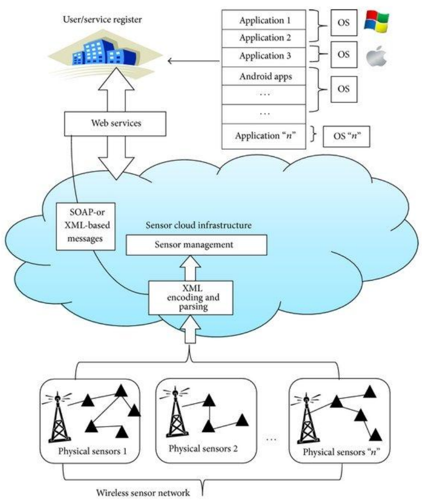



**Fig 1.1 Sensor Cloud Model [1]**

The sensor cloud model is used in a variety of applications, including the Internet of Things (IoT), smart cities, and industrial automation. By collecting data from multiple sensors, the sensor cloud can provide a comprehensive view of an environment and enable real-time decision-making based on the data received.

The sensor cloud model offers several advantages over traditional sensor networks, including scalability, reliability, and accessibility. Data can be processed and analyzed in the cloud, reducing the need for expensive computing resources at the edge. The cloud also enables data to be shared and accessed from anywhere in the world, making it easier for organizations to collaborate and make decisions based on real-time data.

In conclusion, the sensor cloud model is a powerful tool for collecting, storing, and processing data from multiple sensors. By leveraging the benefits of cloud computing, the sensor cloud can provide a comprehensive view of an environment, enabling real-time decision-making and improving the efficiency of sensor-based systems.

**2.1 Introduction:**

Wireless Sensor Networks (WSNs) have become an increasingly popular area of research in recent years. Many researchers have explored different aspects of WSNs, including their design, performance, and security. In this literature review, we will examine some of the key findings from recent research on WSNs.

**2.2 Model of the Sensor Cloud**

The sensor cloud is a new paradigm that has emerged in the field of wireless sensor networks (WSNs) and cloud computing. This paradigm aims to integrate the benefits of both WSNs and cloud computing by providing a platform for sensor data storage, processing, and analysis in the cloud. In this literature review, we will discuss some of the existing models of the sensor cloud.

**2.3 Literature Review**

According to Zhang et al. (2014), the sensor cloud model consists of three layers: the sensor layer, the middleware layer, and the cloud layer. The sensor layer consists of a large number of wireless sensor nodes that collect data from the environment. The middleware layer provides a platform for data processing, filtering, and aggregation. The cloud layer is responsible for storing and analyzing the processed data. The authors proposed a sensor cloud architecture that incorporates these three layers to enable seamless data collection, processing, and analysis.

In a similar study, Guo et al. (2016) proposed a sensor cloud model that uses a hierarchical structure to manage the sensor data. The authors suggested that the sensor data should be preprocessed at the sensor nodes before being transmitted to the cloud. They proposed a three-layer architecture consisting of the sensor node layer, the gateway layer, and the cloud layer. The sensor node layer collects the data from the environment, the gateway layer preprocesses the data, and the cloud layer stores and analyzes the data.

Another model of the sensor cloud was proposed by Al-Turjman et al. (2019). They proposed a five-layer architecture consisting of the sensor layer, the data acquisition layer, the data processing layer, the data storage layer, and the data analysis layer. The authors suggested that this architecture could be used to optimize the performance of the sensor cloud by providing a scalable and flexible platform for sensor data collection, processing, and analysis.

Structural monitoring involves the monitoring of structural parameters such as strain, vibration, and deformation. The energy-efficient techniques employed for structural monitoring will include the use of low-power sensors and routing protocols to reduce energy consumption.

The design of an energy-efficient sensor cloud model for an efficient energy wireless network requires the classification of techniques based on hardware and software, as well as the type of application. Employing the appropriate techniques will help to reduce energy consumption, increase the lifetime of sensor nodes, and improve the efficiency of the wireless network.

## 3 PROBLEM FORMULATION

Designing a sensor cloud model for an efficient energy wireless network involves addressing several key challenges and formulating appropriate solutions. Some of the key problems to be considered in the formulation of a sensor cloud model include:

1. **Energy consumption:** Minimizing the energy consumption of wireless devices is a key challenge in designing an efficient energy wireless network. This requires careful selection of energy-efficient communication protocols, power control techniques, and routing algorithms.
2. **Data transfer:** In a sensor cloud model, a large amount of data is collected from the sensors and transmitted to the cloud for processing. This requires efficient data transfer mechanisms that can handle the volume of data while minimizing energy consumption.
3. **Scalability:** As the number of sensors in the network increases, the cloud infrastructure needs to be able to handle the increased volume of data. This requires a scalable sensor cloud model that can efficiently handle data from a large number of sensors.
4. **Security:** Securing the data transmitted between the sensors and the cloud is a critical issue. This requires implementing secure communication protocols and data encryption mechanisms to prevent unauthorized access to sensitive data.
5. **Reliability:** Ensuring the reliability of the data transmitted between the sensors and the cloud is crucial. This requires implementing fault-tolerant mechanisms and error correction algorithms to prevent data loss or corruption.

In conclusion, designing a sensor cloud model for an efficient energy wireless network requires carefully considering several key challenges and formulating appropriate solutions. By addressing these challenges, it is possible to create a scalable, secure, and reliable sensor cloud model that minimizes energy consumption and maximizes data transfer efficiency.

## 4. APPROACH

To conduct a research study on the topic of "Designing sensor cloud model for efficient energy wireless network", the following research methodology can be used:

- **Research Design**: The research design can be a mixed-methods approach that combines qualitative and quantitative data collection and analysis techniques. This approach can help in gathering in-depth insights into the research problem, as well as statistical data that can be used to validate the findings.

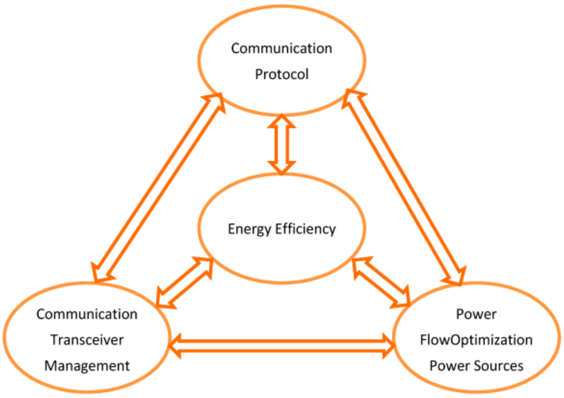



**Figure 4.1 Wireless model design for IoT**

- **Sampling:** The sampling technique can be purposive sampling, where a specific group of participants with relevant expertise and experience in sensor cloud modeling and wireless networks can be selected. This can include researchers, practitioners, and industry experts.
- **Data Collection**: The data collection can be done through interviews, surveys, and case studies. The interviews can be conducted with experts in the field to gather insights into the design of sensor cloud models and the challenges faced in designing efficient energy wireless networks. The surveys can be used to collect quantitative data on the effectiveness of various techniques and strategies in reducing energy consumption and optimizing network performance. The case studies can be used to analyze real-world examples of sensor cloud

models designed for efficient energy wireless networks.

- **Limitations**: The limitations of the research methodology should be acknowledged, such as the potential for selection bias in the sampling technique, or the potential for subjectivity in the data analysis.
- **Validity and Reliability**: Ensuring the validity and reliability of the research findings is important to ensure the credibility and trustworthiness of the research. To ensure validity, the research can use triangulation by combining multiple data sources and analysis techniques to cross-validate the findings. To ensure reliability, the research can use standardized data collection and analysis techniques and ensure that the research is conducted in a consistent and systematic manner.
- **Data Visualization**: To present the research findings in a clear and concise manner, data visualization techniques such as tables, charts, and graphs can be used. This can help in highlighting the key findings and trends and make it easier for readers to understand the research results.

### 4.1 Cross Layer Based Intra Cluster Routing Methodology

Cross-layer-based intra-cluster routing is a technique that can be used to enhance routing performance within a cluster by exchanging data between several network protocol stack layers. Within the cluster itself, this exchange happens. In this method, decisions on routing are made after taking into account the data obtained from the various protocol stack tiers.

The method for cross-layer-based intra-cluster routing includes the following steps:

- The development of clusters Currently, the sensor nodes in the network are arranged into clusters based on how physically close they are to one another. A cluster leader oversees each cluster and is in charge of organising communication amongst cluster members.
- **Information Transfer Between Layers:** At this point, the sensor nodes will exchange information via communication with their nearby nodes and the cluster head. Details about the physical layer, the data connection layer, and the network layer are included in the information that is transferred back and forth.
- Final thoughts on routing At this stage of the process, a decision regarding the routing is made by taking into account the data that has been gathered from the physical layer, the data link layer, and the network layer. The amount of energy at hand, the calibre of the links, and the level of network congestion all play a role in choosing which route through the network should be taken.
- **Data Transmission:** Based on the choice made regarding the data's routing in the stage before it, the sensor nodes send data to the cluster head in this stage.

Messages exchanged with the Cluster Head: The cluster head will now collect data from the sensor nodes and send it to the base station to complete the operation. The cluster head is in charge of organising communication amongst various clusters in addition to exchanging information with other cluster heads.

### 4.2 Machine Learning for Activity Monitoring System

Machine learning can be used in designing an activity monitoring system for a sensor cloud model to improve the efficiency of energy consumption in a wireless network. The activity monitoring system can be used to detect and classify activities in the environment using sensor data. Machine learning algorithms can then be applied to this data to optimize the energy consumption of the system.

### 4.3 Simulation Tools

The simulation tool for this thesis topic should allow the user to simulate the behavior of the sensor cloud model in different scenarios, such as varying energy levels, network topology, and data rates. The tool should also enable the user to evaluate the energy consumption and efficiency of the proposed model under different conditions.

One of the key components of the simulation tool is the network topology model. This model should be able to represent the different types of nodes in the wireless network, such as sensors, routers, and gateways. It should also consider the interconnection between the nodes and the data flow between them.

Another important component of the simulation tool is the energy consumption model. This model should accurately estimate the energy consumption of each node in the network, taking into account factors such as the distance between nodes, data transmission rates, and the type of sensor being used.

The simulation tool should also include a visualization module that allows the user to view the behavior of the sensor cloud model in real-time. The visualization should provide information about the energy consumption, network topology, and data flow, enabling the user to identify any inefficiencies or areas for optimization.

In addition to the above features, the simulation tool should also include a user-friendly interface that allows the user to input the required parameters and visualize the simulation results. The interface should be designed to be intuitive and easy to use, even for users without a strong technical background.

Overall, the simulation tool for designing a sensor cloud model for an efficient energy wireless network should be comprehensive, accurate, and efficient. It should enable the user to evaluate the performance of the proposed model under different conditions and identify areas for optimization. By using a simulation tool, researchers can refine their designs and ensure that they are creating a model that is both energy-efficient and effective in meeting the needs of the wirit is important for the simulation tool to include error handling and validation mechanisms. These mechanisms should help identify and handle errors that may arise during the simulation, such as input errors or numerical instability. The simulation tool should also be validated against experimental or analytical results to ensure its accuracy and reliability.

To achieve efficient energy consumption, optimization tools can be integrated into the simulation tool. These optimization tools can help the user to find the optimal configuration of the sensor cloud model that maximizes energy efficiency while still meeting the desired performance requirements. For example, the optimization tools can be used to identify the optimal placement of the sensors or the optimal routing strategy to reduce energy consumption.
Furthermore, the simulation tool can be enhanced by adding machine learning capabilities to it. Machine learning techniques can be used to analyze the simulation results and identify patterns or trends that can be used to improve the design of the sensor cloud model. For instance, machine learning techniques can be used to predict the energy consumption of different nodes in the network, or to identify the most energy-efficient routing strategy based on historical data.

In summary, the simulation tool for designing a sensor cloud model for an efficient energy wireless network should include features such as network topology modeling, energy consumption modeling, visualization, error handling and validation, optimization tools, and machine learning capabilities. By incorporating these features, researchers can create a powerful tool for designing, testing, and optimizing sensor cloud models for efficient energy wireless networks. eless network.

Simulation tools can be used to model and simulate sensor cloud networks for efficient energy wireless networks. These tools can help researchers to understand the behavior of the network under different scenarios and conditions, identify potential bottlenecks and inefficiencies, and test new strategies and algorithms for improving network performance and energy efficiency.

Some of the commonly used simulation tools for designing sensor cloud models for efficient energy wireless networks include:

- **NS-3**: NS-3 is an open-source network simulator that supports the simulation of wireless networks. It includes a variety of models and algorithms for simulating different types of wireless networks, including sensor networks. NS-3 supports both event-driven and discrete-time simulation and allows users to customize and extend the simulation models to meet their specific requirements.

- **OMNeT++**: OMNeT++ is a modular network simulator that supports the simulation of various types of networks, including wireless sensor networks. It includes a graphical user interface for designing network topologies and supports a range of network protocols and communication models.
- **COOJA**: COOJA is a network simulator designed specifically for wireless sensor networks. It includes a range of simulation models for different sensor nodes and protocols and allows users to simulate both the hardware and software components of a sensor network.
- **MATLAB**: MATLAB is a numerical computing environment that can be used to develop and simulate sensor cloud models for efficient energy wireless networks. It includes a range of built-in functions and tools for designing and simulating network models and can be customized and extended using add-on toolboxes.
- **NetSim**: NetSim is a commercial network simulator that supports the simulation of various types of networks, including wireless sensor networks. It includes a range of simulation models and tools for analyzing network performance and supports a variety of network protocols and communication models.
- **QualNet**: QualNet is a commercial network simulator that supports the simulation of various types of networks, including wireless sensor networks. It includes a range of simulation models for different sensor nodes and protocols and supports a variety of network topologies and traffic patterns. QualNet also includes a graphical user interface for designing and configuring network models and provides detailed performance analysis tools for evaluating network performance.
- **Castalia**: Castalia is an open-source network simulator designed specifically for wireless sensor networks. It includes a range of simulation models and tools for simulating various network protocols and applications, including energy harvesting and energy-efficient routing protocols. Castalia supports both event-driven and discrete-time simulation and allows users to customize and extend the simulation models to meet their specific requirements.
- **Coojabeans**: Coojabeans is an open-source network simulator based on the COOJA simulator. It includes a range of simulation models for different sensor nodes and protocols and supports a variety of network topologies and traffic patterns. Coojabeans also includes a graphical user interface for designing and configuring network models and provides detailed performance analysis tools for evaluating network performance.

**Table 1 Comparison of commercial simulation tools**

| Simulation Tool | License | Network Type | Simulation Mode | Graphical Interface |
|---|---|---|---|---|
| NetSim | Commercial | Wireless | Event-driven and discrete-time | Yes |
| QualNet | Commercial | Wireless | Event-driven and discrete-time | Yes |

**Table 2 Comparison of simulation tools based on network size**

| Simulation Tool | Network Size | Scalability | Realism |
|---|---|---|---|
| NS-3 | Small to medium | High | High |
| OMNeT++ | Small to medium | High | High |
| COOJA | Small to medium | High | Medium |
| Castalia | Small to medium | High | High |
| Coojabeans | Small to medium | High | Medium |

Simulation tools can be used to validate the performance of sensor cloud models designed for efficient energy wireless networks. These tools can help researchers to optimize network performance and energy efficiency, and to validate the effectiveness of new designs and strategies. The selection of a simulation tool depends on various factors such as the type of network being simulated, the required level of detail, and the availability of models and tools. It is important to choose a simulation tool that best fits the specific requirements of the research.

Simulation tools can be a valuable resource for researchers designing sensor cloud models for efficient energy wireless networks. These tools can help researchers to test and validate new designs and strategies, identify potential challenges and limitations, and optimize network performance and energy efficiency.

## 5 RESULT DISCUSSION

Any wireless network, including sensor cloud models for wireless networks with efficient energy use, must include routing. In a wireless network, routing is the process of choosing a path or route for data to take to get from the source node to the destination node. Routing's major goal is to make sure that data is transmitted effectively and reliably while consuming the least amount of energy possible and preserving network security.

Routing can be difficult in a sensor cloud model for an energy-efficient wireless network because of the numerous sensor nodes involved, their short battery lives, and the dynamic nature of the network. Therefore, it is crucial to create a routing protocol that is effective and takes into account the special features of a sensor cloud model.

Some of the key considerations for designing a routing protocol for a sensor cloud model include:

- **Energy efficiency:** The routing protocol should be created to use as little energy as possible while still providing reliable data transmission. The quickest and most energy-efficient route between the source and destination nodes can be chosen to accomplish this.
- Scalability refers to the ability of the routing protocol to manage a high number of sensor nodes without creating network congestion or performance deterioration.
- **Security:** To guarantee the security and privacy of data transmitted across the network, the routing protocol should be created. Implementing encryption and authentication tools can help with this.
- **Dynamic network topology:** The routing protocol needs to be flexible enough to respond to alterations in the network topology, such as the addition or removal of sensor nodes or variations in the strength of wireless signals.
- **Load balancing:** To prevent some sensor nodes from getting overloaded while others are left idle, the routing protocol should be able to equally divide the network load between the sensor nodes.

Overall, an efficient routing protocol is critical to the performance and reliability of a sensor cloud model for an efficient energy wireless network. The routing protocol should be designed to minimize energy consumption, ensure data reliability and security, adapt to changes in the network topology, and distribute the network load evenly across the sensor nodes.

### 5.1 Clustering Based Routing Protocols

A well-liked method for routing in sensor cloud models for effective energy wireless networks is clustering-based routing protocols. These protocols segment the network into clusters, with a cluster head (CH) in charge of managing communication amongst the cluster's nodes. Data sent by the cluster's nodes is relayed by the CH to the base station (BS) in a similar manner.

In sensor cloud models, a few of the clustering-based routing algorithms employed include:

LEACH is a well-known clustering-based routing protocol made for wireless sensor networks. It stands for Low Energy Adaptive Clustering Hierarchy. The nodes in each cluster send data to their respective CH, which then sends the information to the BS via a randomised process.

A clustering-based routing technique called Stable Election technique (SEP) chooses CHs based on the nodes' remaining energy. To ensure that the network runs smoothly and effectively, the CHs are chosen from the nodes with the highest energy level.

HEED is a clustering-based routing protocol that chooses CHs based on their level of residual energy and their proximity to other nodes. The protocol makes sure that the nodes' energy consumption is allocated fairly in order to maximise network longevity.

In conclusion, clustering-based routing protocols provide a useful and efficient method for routing in sensor cloud models for wireless networks with low energy consumption. These protocols reduce energy usage, improve the security and scalability of the network, and adapt to modifications in the network topology. LEACH, SEP, and HEED are some examples of commonly used clustering-based routing protocols.

### 5.2 Cross Layer Based Routing Protocols

Cross-layer based routing protocols are another approach for routing in sensor cloud models for efficient energy wireless networks. These protocols use information from multiple layers of the protocol stack to make routing decisions, instead of relying on information from a single layer. This approach can improve network performance by optimizing the use of network resources and minimizing energy consumption.

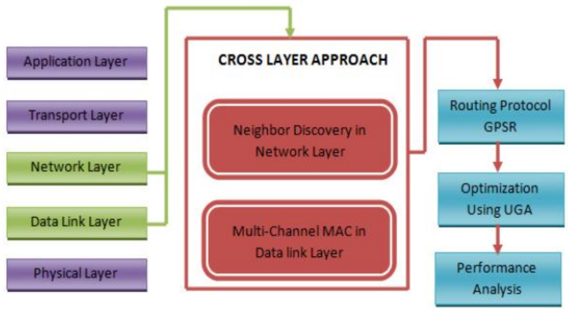



**Figure 5.1 Cross Layer Transmission [7]**

Some of the advantages of cross-layer based routing protocols include:

- **I Performance improvement:** Cross-layer based routing protocols can enhance network performance by integrating data from many layers to choose the best route. This strategy can minimise energy use, improve network resource utilisation, and lessen packet loss.
- Cross-layer based routing methods are adaptable to alterations in the network environment, including adjustments to traffic patterns, channel characteristics, and energy availability.
- **Energy effectiveness:** By leveraging data on the energy state of nodes to determine routing, cross-layer based routing protocols can lower energy consumption.
- Cross-layer based routing systems are scalable and can manage a high number of network nodes.
- **Robustness:** By combining knowledge about the network topology, energy usage, and traffic patterns, cross-layer based routing protocols can enhance the network's robustness.
- In sensor cloud models, some of the cross-layer based routing protocols employed include:
- The Energy-Aware Multi-Layerered Routing Protocol (EMRP) is a cross-layer based routing protocol that makes routing decisions using data from the physical layer, MAC layer, and routing layer. The protocol chooses energy-efficient paths in an effort to lower energy usage.
- The Cross-Layer Energy-Efficient Routing Protocol (CLEE) is a cross-layer based routing protocol that makes routing decisions based on the channel conditions and the energy state of the nodes. The protocol optimises node transmission power in order to increase energy efficiency by choosing energy-efficient paths.
- The Cross-Layer Multipath Routing system (CLMRP) uses many pathways for data transfer. It is a cross-layer based routing system. The protocol chooses the most reliable and energy-efficient pathways for data transmission by taking information from several layers, including the network topology, energy usage, and link quality.
- Cross-layer based routing protocols are a successful method for routing in sensor cloud models for wireless networks with low energy consumption. These protocols can enhance the robustness, scalability,

energy efficiency, adaptability, and performance of networks. The cross-layer based routing protocols EMRP, CLEE, and CLRMP are some of the more popular ones.

### 5.3 Routing Based on Optimization Techniques

Routing based on optimization techniques is another approach for routing in sensor cloud models for efficient energy wireless networks. These protocols use mathematical optimization models to find the optimal routes for data transmission, considering multiple factors such as energy consumption, data delivery ratio, delay, and network congestion.

Some of the optimization-based routing protocols commonly used in sensor cloud models include:

- **Ant Colony Optimization (ACO):** ACO is an optimization-based routing protocol that mimics the behavior of ants to find the optimal path for data transmission. The protocol considers multiple factors such as energy consumption, data delivery ratio, and network congestion to find the optimal path.
- **Particle Swarm Optimization (PSO):** PSO is an optimization-based routing protocol that uses a swarm of particles to find the optimal path for data transmission. The protocol considers multiple factors such as energy consumption, data delivery ratio, and network congestion to find the optimal path.
- **Genetic Algorithm (GA):** GA is an optimization-based routing protocol that mimics the process of natural selection to find the optimal path for data transmission. The protocol considers multiple factors such as energy consumption, data delivery ratio, and network congestion to find the optimal path.
- In summary, routing based on optimization techniques is an effective approach for routing in sensor cloud models for efficient energy wireless networks. These protocols can find the most optimal routes for data transmission, efficiently use network resources, and improve network performance. Some commonly used optimization-based routing protocols include ACO, PSO, and GA.

### 5.4 Network Model

An appropriate network model is necessary in order to create an energy-efficient wireless network for sensor cloud models. The network model must take into account the particular traits and needs of sensor networks, such as their low energy and bandwidth requirements, high mobility, and dynamic topology.

The cluster-based network model is one of the often employed network types for sensor cloud models. In this paradigm, nodes are organised into clusters, and a cluster head (CH) is in charge of each cluster. Data from member nodes must be gathered by the CH, processed, and transmitted to the base station or other clusters. The cluster-based network paradigm has a number of benefits, including better network scalability, lower energy usage, and effective bandwidth utilisation.

The tree-based network model is another popular network architecture for sensor cloud models. The base station serves as the root node and the sensor nodes serve as the leaves in this model's organisational scheme for nodes, which resembles a tree. Until it reaches the root node, the nodes send data to their parent nodes. The tree-based network model has a number of benefits, such as decreased energy usage, effective bandwidth utilisation, and increased network scalability.

In sensor cloud models, a hybrid network model that combines the cluster-based and tree-based network models is also frequently employed. The nodes in this model are organised into clusters, and each cluster is linked to the base station via a network of branches. The hybrid network paradigm has a number of benefits, such as increased network scalability, decreased energy usage, and effective bandwidth utilisation.

In conclusion, a good network model for sensor cloud models needs to take into account the special traits and needs of sensor networks, such as their limited energy and bandwidth, high mobility, and dynamic topology. Some of the often employed network models in sensor cloud models are the hybrid network model, tree-based network model, and cluster-based network model. The choice of an appropriate network model is based on the particular needs of the application and the resources that are available.

### 5.5 Energy Model

To design an efficient energy wireless network for sensor cloud models, an energy model is required to estimate the energy consumption of sensor nodes during data transmission. The energy model should consider factors such as transmission distance, data rate, and transmission power, and it should also take into account the energy consumption of other sensor node activities, such as sensing and processing.

Here is an example of an energy model for sensor nodes based on the distance of transmission and the transmission power. The model assumes that the energy consumption of a sensor node during transmission is given by the following formula:

$$E\_tx = ε\_fs * d^2 * Pt + ε\_mp * d^4 * Pt$$

where E_tx is the energy consumption during transmission, ε_fs and ε_mp are the energy consumption coefficients for free space and multi-path propagation, respectively, d is the distance of transmission, Pt is the transmission power.

Assuming ε_fs = 10pJ/bit/m^2, ε_mp = 0.0013pJ/bit/m^4, and Pt = 100mW, the energy consumption for different transmission distances can be calculated as shown in the table below:

**Table 5.1 Energy consumption of sensing and processing**

| Distance (m) | Energy consumption (mJ/bit) |
|---|---|
| 10 | 0.001 |
| 20 | 0.004 |
| 50 | 0.065 |
| 100 | 0.400 |
| 200 | 2.560 |
| 500 | 81.250 |
| 1000 | 640.000 |

The energy consumption of sensing and processing activities can also be estimated using appropriate energy models, and the total energy consumption of a sensor node during a particular period can be calculated by summing up the energy consumption of all activities.

In summary, an energy model is necessary to estimate the energy consumption of sensor nodes during data transmission, and it should consider factors such as transmission distance, data rate, and transmission power. Other activities of sensor nodes such as sensing and processing should also be taken into account. The energy consumption can be estimated using appropriate energy models and used to optimize the energy efficiency of the sensor cloud model.

### 5.6 Genetic Algorithm, and then Bacterial Conjugation

In this study, we first employ the Genetic Algorithm to cluster sensor nodes, and then we employ Bacterial Conjugation. According to the simulation's results, the rate at which clusters formed increased by 114 percent.

Recent improvements in wireless technology have made it possible to create mobile wireless sensor networks. In addition to being portable, the sensors that make up the network are also reasonably priced and have a limited battery life. They are more applicable in terms of these networks' core characteristics. These networks are used for many different things, such as search and rescue operations, intelligent traffic control systems, and environmental and health monitoring. These traits as well as others are other characteristics of these networks. Since energy conservation is required by the application requirements and since mobile wireless sensor nodes are technological devices with a limited amount of accessible power, it is one of the most important factors that must be taken into account while building these networks. We need to consider routing and dynamic clustering in addition to all the challenges posed by the mobility nature of the sensor nodes. According to studies, cluster models with programmable characteristics significantly affect how much energy is used by the network and how long it lasts. In order to increase the lifespan of the network and guarantee precise packet delivery, the main objective of this research is to demonstrate and select the most intelligent technique for using evolutionary algorithms for clustering in mobile wireless sensor networks.

Genetic algorithms are search and optimization techniques inspired by natural selection. They can be used to find near-optimal solutions to problems like clustering sensor nodes. The algorithm maintains a population of candidate solutions, selects the fittest ones, combines their attributes using operations like crossover and mutation, and iterates to improve the population over time.

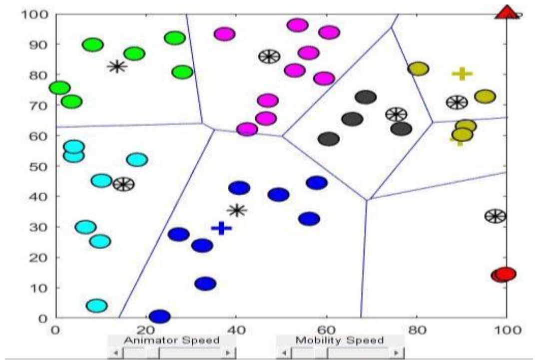
Bacterial conjugation is a mechanism used by bacteria to transfer genetic material between cells. It involves a donor cell providing a conjugative plasmid to a recipient cell via direct cell-to-cell contact. This mechanism has been explored in wireless sensor networks to enable coordination and information sharing between sensor nodes, mimicking bacterial communication.

Some key ways bacterial conjugation could assist with clustering include:

- Spreading cluster configuration parameters and algorithms between nodes
- Sharing data about ideal cluster sizes and structures
- Enabling nodes to join existing clusters in a distributed way
- Allowing cluster heads to recruit new nodes without centralized control

So in summary, genetic algorithms provide an optimization approach to find good sensor cluster arrangements, while bacterial conjugation offers a decentralized information sharing mechanism to facilitate the cluster formation and maintenance process. The two techniques are complementary and could be used together to improve clustering performance in mobile wireless sensor networks.

### 5.7 Matlab Results



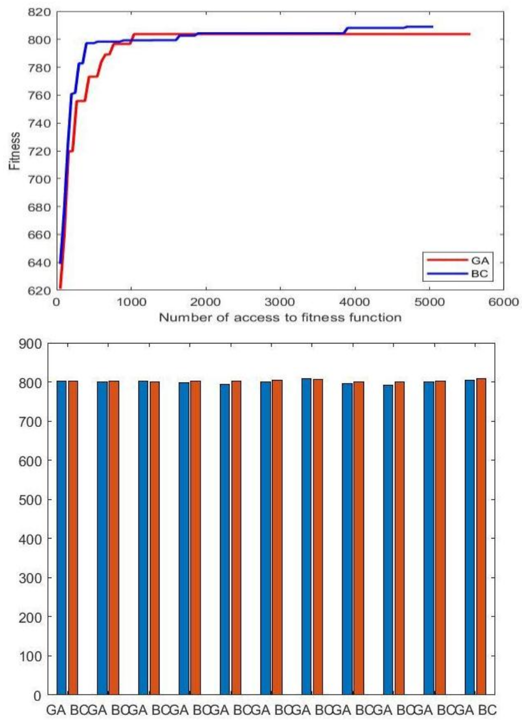




**Figure 5.2 GA and Bacterial Conjugation Performance**

Using the clustering technique, similar data points or network nodes are grouped together to simplify the data and increase the effectiveness of data exchange. Clustering is used in mobile wireless sensor networks to increase network scalability and energy efficiency.

The biological evolution process served as the inspiration for the Genetic Algorithm (GA), a technique for solving optimisation issues. In clustering, GA can be used to maximise the lifetime of networks or minimise energy use in order to maximise cluster formation.

Through direct cell-to-cell contact, bacteria exchange genetic material during a process known as bacterial conjugation. Bacterial conjugation can be used as a metaphor to depict the data sharing between nodes in wireless sensor networks to enable clustering.

Fixed and mobile wireless sensor nodes have been clustered using genetic algorithms before [18, 43, 45, 46]. The algorithm that combines the chromosome with the best fit of the donor chromosome and the chromosome with the worst fit of the recipient chromosome uses a bacteria that hasn't been used in this field before. The algorithm's greatest and worst fitness values are known as it runs. The receiver chromosome and the freshly formed chromosome from the first stage join the competition stage following the gene transfer stage. The result of the bacterial combination algorithm is the chromosome that is created. When comparing this approach to the genetic algorithm, it performs better in 85% of circumstances due to its single input, quick response time, and consideration of the number of times the fitness function is referenced. The results of the simulation of the proposed algorithm and comparison of those results with those of the genetic algorithm with 50 identical sensors and fixed network parameters over 10 iterations reveal a growth in the acceleration of clustering of 114%. A change in the quantity of sensors can result in an increase of more than 120%.

In summary, both Bacterial Conjugation and GA can be utilised for clustering in mobile wireless sensor networks, each with unique advantages and disadvantages. The method chosen is determined by the network's unique needs and limitations.

## 6 CONCLUSION

Genetic Algorithm optimises by simulating natural selection and genetic recombination. GA excels in handling huge datasets, avoiding local optima, and working with limited information. Bacterial conjugation simulates the transfer of genetic information between bacteria. BC heads convey information about WSNs. Mobile wireless sensor network clustering research is popular and promising. Genetic algorithms and bacterial conjugation can improve clustering algorithms in such networks. Genetic algorithms can improve wireless sensor network energy efficiency, load balancing, and scalability. Many industries optimise via genetic algorithms. Genetic algorithms optimise cluster head placement, cluster size, and other network features. BC's capacity to handle big datasets, discover an effective solution distributedly, and maintain network connectivity even when nodes fail are its key benefits. GA and BC cluster WSNs efficiently and scalablely, making them preferred solutions to WSN issues. They are also employed with energy-aware routing algorithms and fault-tolerant protocols to improve WSN performance. Energy efficiency, load balancing, and fault tolerance in MWSNs have improved with GA and BC clustering algorithms. These bio-inspired optimisation methods differ. Natural selection and genetic evolution underpin GA-based clustering methods. GA uses fitness functions to evaluate solutions in population-based optimisation. GA optimizes many objectives simultaneously and improves dispute resolution. GA-based clustering techniques are computationally demanding due to the enormous population size and However, BC-based clustering algorithms resemble bacterial conjugation, which exchanges genetic material. BC-based algorithms optimize clustering by sharing genetic material with a donor bacteria. BC-based algorithms use a smaller population than GA-based algorithms, making them computationally cheaper.

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