CLUSTER OPTIMIZATION IN WIRELESS SENSOR NETWORK USING GENETIC ALGORITHM AND BACTERIAL CONJUGATION

Amy Alice Kujur

Assistant Professor
Department of Electronics and communication
IGEC Sagar

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 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 GA and BC in clustering algorithms for MWSNs. GA is a population-based optimization technique that mimics natural selection and genetic evolution to find optimal solution. 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 MWSNs. The article discusses the advantages and differences of these two techniques in the context of clustering algorithms for MWSNs. 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 GA and BC to develop more sophisticated clustering algorithms that efficiently handle the dynamic and heterogeneous nature of MWSNs. These algorithms could improve the overall performance of MWSNs by addressing issues such as energy efficiency, load balancing, and fault tolerance. In conclusion, GA and BC are promising optimization strategies for clustering in MWSNs. The article provides insights into the advantages and differences of these two techniques and highlights their potential for future development in the field of clustering algorithms for MWSNs. This research has implications for improving the efficiency and effectiveness of MWSNs for various applications, including environmental monitoring, disaster management, and healthcare.**

Keywords: **Genetic Algorithm, Bacterial Conjugation, Clustering, Mobile wireless sensor network, optimization.**

INTRODUCTION

I. General Introduction

Wireless Sensor Networks (WSNs) are networks composed of small, autonomous sensor nodes that are wirelessly interconnected to monitor and collect data from the physical environment. These sensor nodes are equipped with various sensors to measure and capture different parameters such as temperature, humidity, light, sound, motion, and more. The collected data is transmitted through the network to a central base station or sink node for processing and analysis.

1. Environmental monitoring: WSNs play a crucial role in monitoring and managing the environment in areas such as forest ecosystems, air quality, water resources, and natural disaster detection. They provide real-time data on factors like temperature, air pollution levels, water quality, and enable timely decision-making for environmental conservation and disaster mitigation.
2. Industrial automation: WSNs are extensively used in industrial settings for process monitoring, control, and optimization. They enable real-time monitoring of parameters like temperature, pressure, vibration, and energy consumption in factories, oil refineries, power plants, and other industrial facilities. WSNs improve efficiency, reduce costs, and enhance safety in industrial processes.
3. Healthcare: WSNs have significant applications in healthcare monitoring and patient care. They can be used for remote monitoring of vital signs, tracking patient movement, medication adherence, and fall detection for the elderly. WSNs facilitate continuous healthcare monitoring and enable timely intervention in case of emergencies or critical conditions.
4. Smart cities: WSNs contribute to the development of smart cities by providing real-time data on traffic congestion, air quality, waste management, and energy consumption. They enable efficient resource allocation, traffic management, and environmental monitoring, leading to improved urban planning, sustainability, and quality of life for city dwellers.
5. Agriculture: WSNs are employed in precision agriculture for crop monitoring, irrigation control, and pest detection. Sensor nodes measure soil moisture, temperature, humidity, and nutrient levels, allowing farmers to optimize irrigation, fertilization, and pest control practices. WSNs enhance agricultural productivity, minimize resource wastage, and support sustainable farming.
6. Structural health monitoring: WSNs are utilized for monitoring the structural health of buildings, bridges, and infrastructure. They detect changes in structural parameters such as vibrations, strain, and cracks, enabling early identification of potential failures or maintenance requirements. WSNs contribute to ensuring the safety and integrity of critical structures.

7. Wildlife and habitat monitoring: WSNs aid in wildlife tracking, habitat monitoring, and biodiversity conservation efforts. Sensor nodes equipped with motion and sound sensors detect and record animal movement patterns, habitat conditions, and species presence. WSNs provide valuable data for wildlife research, habitat conservation, and environmental management.

The importance of wireless sensor networks lies in their ability to collect real-time data, enable remote monitoring, and facilitate decision-making in various domains. Their applications span across environmental, industrial, healthcare, urban, agricultural, and ecological contexts, offering immense potential for improving efficiency, sustainability, and quality of life.

II. Architecture of Wireless Sensor Networks

A. Sensor nodes:

1. Sensor capabilities and functions:

Sensor nodes in a WSN are equipped with various types of sensors that enable them to capture and measure physical parameters in the environment. These sensors can include temperature sensors, humidity sensors, light sensors, motion sensors, pressure sensors, gas sensors, and more. Each sensor node can have one or multiple sensors integrated into it, depending on the application requirements.

The sensors within the nodes are responsible for collecting data from the environment. They convert physical phenomena into electrical signals that can be processed and transmitted within the network. The data collected by the sensors is typically in analog form and needs to be converted into digital format for further processing and communication.

2. Resource constraints:

Sensor nodes in WSNs operate under resource-constrained conditions. They have limited processing capabilities, storage capacity, and energy supply. Due to their small size and low-cost design, sensor nodes often have low computational power and memory. Additionally, they are usually powered by batteries or energy harvesting techniques, which means that energy conservation, is crucial for prolonging the network's lifetime.

B. Communication infrastructure:

1. Wireless communication technologies:

Wireless communication is a fundamental aspect of WSNs, enabling sensor nodes to exchange data and coordinate their operations. Different wireless communication technologies can be used in WSNs, including radio frequency (RF) communication, infrared (IR) communication, and sometimes even acoustic communication.

RF communication is the most commonly used technology in WSNs. It allows sensor nodes to communicate with each other over radio waves using various protocols and frequency bands. RF communication provides the advantage of longer communication ranges and the ability to penetrate obstacles. Different RF communication standards like Zigbee, Bluetooth, and Wi-Fi can be utilized in WSNs based on the specific requirements of the application.

2. Network topologies:

WSNs can be structured using different network topologies based on the application needs and network characteristics. Some common network topologies used in WSNs include:

- Star Topology: In this topology, all sensor nodes communicate directly with a central base station or sink node. The base station acts as a gateway for data aggregation and processing.
- Mesh Topology: In a mesh topology, sensor nodes are interconnected in a multi-hop manner. Each sensor node can communicate with its neighboring nodes, forming a mesh network. Mesh topologies provide robustness and redundancy but require more complex routing algorithms.
- Tree Topology: In a tree topology, sensor nodes are organized in a hierarchical structure, with a root node at the top and child nodes branching out. Data is transmitted from leaf nodes to the root node through intermediate nodes. Tree topologies are suitable for applications that require data aggregation and hierarchical communication.

The choice of network topology depends on factors such as the network size, communication range, power consumption, scalability, and data routing requirements. Understanding the architecture of WSNs involves considering the capabilities and constraints of sensor nodes, as well as the wireless communication technologies and network topologies employed. This architecture forms the foundation for efficient data gathering, communication, and collaboration within the network.

III. Communication Protocols in Wireless Sensor Networks

A. Medium Access Control (MAC) protocols:

Medium Access Control protocols in WSNs determine how sensor nodes access the shared wireless medium for transmission. These protocols handle issues such as channel allocation, contention resolution, and collision avoidance. Some commonly used MAC protocols in WSNs include:

- Carrier Sense Multiple Access (CSMA): CSMA-based protocols sense the medium before transmitting to avoid collisions. Examples include CSMA/CA (Carrier Sense Multiple Access with Collision Avoidance) and CSMA/CD (Carrier Sense Multiple Access with Collision Detection).
- Time Division Multiple Access (TDMA): TDMA protocols allocate specific time slots to different nodes, ensuring exclusive access to the medium during their assigned time slots.
- Random Access Protocols: Random access protocols, such as ALOHA and slotted ALOHA, allow nodes to transmit data randomly, dealing with collisions through retransmission strategies.

B. Routing protocols:

Routing protocols in WSNs determine the paths that data packets take to reach their destination. The choice of routing protocol depends on factors such as network size, energy efficiency, scalability, and application requirements. Some common routing protocols used in WSNs include:

1. Direct transmission:

In direct transmission, sensor nodes directly transmit data to a base station or sink node without any intermediate nodes. This approach is suitable for small networks where the base station is within the communication range of all sensor nodes. However, it may lead to energy imbalances if some nodes are farther from the base station and consume more energy for transmission.

2. Multi-hop routing:

Multi-hop routing protocols enable data transmission through intermediate nodes in a hop-by-hop manner. Each node forwards data packets to the next hop until they reach the destination. Examples of multi-hop routing protocols include Ad hoc On-Demand Distance Vector (AODV), Dynamic Source Routing (DSR), and Destination-Sequenced Distance Vector (DSDV). These protocols provide flexibility and can handle larger network sizes.

3. Hierarchical routing:

Hierarchical routing protocols divide the network into clusters or hierarchies to reduce the overhead of long-distance communication and increase network scalability. They introduce the concept of cluster heads or super nodes that aggregate and forward data from member nodes within their clusters. Examples of hierarchical routing protocols include LEACH (Low Energy Adaptive Clustering Hierarchy) and HEED (Hybrid Energy-Efficient Distributed clustering).

C. Data aggregation techniques:

Data aggregation aims to reduce redundant and unnecessary data transmission within the network, saving energy and network resources. Aggregation techniques allow nodes to collect, compress, and summarize data before transmitting it to the base station. Aggregated data reduces the overall amount of transmitted data and enables efficient data processing. Common data aggregation techniques include spatial and temporal correlation-based aggregation, data fusion, and compressive sensing.

Communication protocols in WSNs, including MAC protocols, routing protocols, and data aggregation techniques, are essential for efficient and reliable data transmission. They address challenges such as energy conservation, network scalability, and data processing, ensuring effective communication and maximizing the network's performance.

IV. Energy Management in Wireless Sensor Networks

A. Energy consumption analysis:

Understanding the energy consumption patterns of sensor nodes is crucial for effective energy management in WSNs. Energy consumption analysis involves measuring and quantifying the energy consumed by different components of a sensor node, such as the sensors, processor, memory, and communication modules. This analysis helps in identifying energy-intensive operations and optimizing their usage to prolong the network's lifetime.

B. Power-efficient routing protocols:

Power-efficient routing protocols aim to minimize energy consumption during data transmission in WSNs. These protocols consider factors such as the remaining energy levels of sensor nodes, the distance between nodes, and the quality of wireless links. By selecting energy-efficient routes and avoiding long-distance transmissions, power-efficient routing protocols reduce energy consumption and extend the network's lifetime. Examples of power-efficient routing protocols include Energy-Efficient Routing (EER), Energy-Aware Routing (EAR), and Minimum Energy Routing (MER).

C. Sleep scheduling and duty cycling:

Sleep scheduling and duty cycling techniques aim to conserve energy by putting sensor nodes into low-power sleep states when they are not actively participating in data sensing or communication. Sleep scheduling involves dynamically activating and deactivating sensor nodes based on the network requirements and data traffic patterns. Duty cycling techniques specify the duty cycle of a node, which determines the fraction of time it remains active versus in sleep mode. By adjusting sleep schedules and duty cycles, energy consumption can be significantly reduced, particularly during periods of low data activity.

D. Energy harvesting techniques:

Energy harvesting techniques involve capturing and utilizing energy from the environment to power sensor nodes in WSNs. These techniques leverage renewable energy sources such as solar energy, wind energy, vibration, or thermal energy to supplement or replace battery power. Energy harvesting modules, such as solar panels or piezoelectric transducers, can be integrated into sensor nodes to harvest energy from the surroundings. Energy harvested can be used to recharge batteries or directly power the nodes, reducing the dependence on finite energy sources and enhancing the network's sustainability. Efficient energy management in WSNs is critical for extending the network's lifetime and ensuring reliable operation. By analyzing energy consumption, employing power-efficient routing protocols, implementing sleep scheduling and duty cycling, and harnessing energy from the environment, WSNs can achieve optimal energy utilization, prolonging network operation and reducing maintenance efforts.

V. Security in Wireless Sensor Networks

A. Security challenges:

Wireless Sensor Networks face various security challenges due to their distributed nature, resource constraints, and wireless communication. Some common security challenges in WSNs include:

1. Limited resources: Sensor nodes have limited processing power, memory, and energy, making it challenging to implement complex security mechanisms.
2. Wireless communication vulnerabilities: Wireless transmission is susceptible to eavesdropping, interception, and unauthorized access, making data privacy and confidentiality a concern.

3. Node compromise: Sensor nodes can be physically compromised or tampered with, leading to unauthorized access and malicious activities.
4. Network scalability: As the network size grows, it becomes more challenging to secure a large number of nodes and maintain secure communication.

B. Encryption and authentication:

Encryption and authentication techniques are essential for ensuring secure communication and data privacy in WSNs.

1. Encryption: Encryption algorithms, such as Advanced Encryption Standard (AES) or Rivets Cipher (RC), are used to encrypt data before transmission. This ensures that only authorized entities can decrypt and access the data.
2. Authentication: Authentication mechanisms, such as digital signatures and message authentication codes (MAC), verify the integrity and authenticity of messages exchanged between sensor nodes. They prevent unauthorized nodes from tampering with or injecting false data into the network.

C. Key management:

Key management is crucial for secure communication in WSNs. It involves the generation, distribution, storage, and updating of cryptographic keys used for encryption, decryption, and authentication.

1. Key establishment: Secure key establishment protocols, like Diffie-Hellman key exchange or Elliptic Curve Cryptography (ECC), are used to establish shared keys between sensor nodes.
2. Key distribution: Key distribution protocols ensure that cryptographic keys are securely distributed to authorized nodes. Techniques such as pre-distribution of keys, key predistribution schemes, or key establishment on-demand can be employed.
3. Key revocation and updating: Revocation mechanisms are necessary to handle compromised or compromised nodes, ensuring that revoked keys are no longer used for communication. Regular key updating enhances the security of the network by reducing the risk associated with long-term key usage.

D. Intrusion detection and prevention:

Intrusion detection and prevention systems play a crucial role in identifying and mitigating security threats in WSNs. These systems monitor the network for malicious activities, anomalous behavior, and intrusion attempts.

1. Anomaly detection: Anomaly-based intrusion detection techniques analyze the behavior of sensor nodes and detect any deviations from normal patterns. Statistical methods, machine learning algorithms, or rule-based systems can be employed for anomaly detection.
2. Misbehavior detection: Misbehavior detection mechanisms aim to identify nodes that deviate from the network's expected behavior or violate protocol rules. Techniques like reputation-based systems or watchdog approaches can be used to identify and isolate misbehaving nodes.
3. Secure routing protocols: Secure routing protocols incorporate security mechanisms to protect against routing attacks, such as selective forwarding, sinkhole attacks, or Sybil attacks. These protocols ensure that data is transmitted through trusted paths and prevent unauthorized nodes from manipulating or disrupting routing operations.

Ensuring security in WSNs is essential to protect sensitive data, maintain the integrity of the network, and prevent unauthorized access or malicious activities. By implementing encryption and authentication, establishing robust key management mechanisms, and deploying intrusion detection and prevention systems, the security of WSNs can be enhanced.

RESEARCH METHODOLOGY

Research methodology refers to the systematic approach used to conduct research and gather information in order to answer research questions or achieve research objectives. It outlines the overall strategy, techniques, and tools employed in a study. Here are the key components typically included in a research methodology:

1. **Research Design:** This involves selecting and designing the overall structure and plan for the study. Common research designs include experimental, observational, qualitative, and quantitative approaches. The research design should align with the research objectives and the nature of the research questions.
2. **Data Collection Methods:** The research methodology should specify the methods used to collect data. This may include techniques such as surveys, interviews, observations, experiments, or document analysis. The chosen methods should be appropriate for the research objectives and allow for the collection of relevant and reliable data.
3. **Sampling:** If the study involves selecting a subset of the population for data collection, the research methodology should describe the sampling technique used. Common sampling techniques include random sampling, stratified sampling, convenience sampling, or purposive sampling. The methodology should explain how the sample was selected and why it is representative of the target population.
4. **Data Analysis:** The research methodology should outline the methods and techniques used to analyze the collected data. This may include qualitative analysis techniques such as thematic analysis, content analysis, or discourse analysis, as well as quantitative analysis methods such as statistical analysis, regression analysis, or data mining. The chosen analysis methods should be appropriate for the type of data collected and the research questions.
5. **Ethical Considerations:** Research ethics are essential to ensure the protection of participants and the integrity of the research. The research methodology should address any ethical considerations, such as obtaining informed consent, ensuring participant confidentiality, and adhering to ethical guidelines or institutional review board (IRB) requirements.
6. **Limitations:** It is important to acknowledge the limitations of the research methodology. This may include factors such as sample size limitations, potential biases, or constraints in data collection and analysis. Recognizing and discussing limitations helps to establish the scope and validity of the research findings.

By providing a clear and detailed research methodology, researchers can ensure the transparency, rigor, and reliability of their study. The methodology section allows readers to understand how the research was conducted and to evaluate the reliability and validity of the find in Result Discussion. Routing is a critical component of any wireless network, including sensor cloud models for efficient energy wireless networks. Routing refers to the process of selecting a path or route for data to travel from the source node to the destination node in a wireless network. The primary objective of routing is to ensure that data is transmitted efficiently and reliably, while minimizing energy consumption and maintaining network security.

In a sensor cloud model for an efficient energy wireless network, routing can be challenging due to the large number of sensor nodes involved, the limited battery life of these nodes, and the dynamic nature of the network. Therefore, it is essential to design an efficient routing protocol that takes into account the unique characteristics 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 designed to minimize energy consumption while ensuring that data is transmitted reliably. This can be achieved by selecting the shortest and most energy-efficient route between the source and destination nodes.
- **Scalability:** The routing protocol should be scalable, i.e., it should be able to handle a large number of sensor nodes without causing network congestion or degradation of performance.
- **Security**: The routing protocol should be designed to ensure the security and privacy of data transmitted over the network. This can be achieved by implementing encryption and authentication mechanisms.
- **Dynamic network topology**: The routing protocol should be able to adapt to changes in the network topology, such as the addition or removal of sensor nodes or changes in the strength of wireless signals.
- **Load balancing**: The routing protocol should be able to distribute the network load evenly across the sensor nodes, to prevent some nodes from becoming overloaded while others remain idle.

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.

Clustering Based Routing Protocols

Clustering based routing protocols are a popular approach for routing in sensor cloud models for efficient energy wireless networks. These protocols divide the network into clusters, with each cluster having a cluster head (CH) responsible for coordinating communication among the nodes within the cluster. The CH acts as a relay node for data transmitted by the nodes within the cluster and forwards it to the base station (BS).

Some of the clustering-based routing protocols commonly used in sensor cloud models includes:

- Low Energy Adaptive Clustering Hierarchy (LEACH): LEACH is a popular clustering-based routing protocol designed for wireless sensor networks. It uses a randomized algorithm to select CHs, and the nodes in each cluster transmit data to their CH, which in turn forwards the data to the BS.
- Stable Election Protocol (SEP): SEP is a clustering-based routing protocol that selects CHs based on the remaining energy of the nodes. Nodes with the highest energy level are selected as CHs to ensure that the network operates efficiently and effectively.
- Hybrid Energy Efficient Distributed Clustering (HEED): HEED is a clustering-based routing protocol that selects CHs based on their residual energy level and their proximity to other nodes. The protocol aims to maximize the network lifetime by ensuring that the energy consumption of the nodes is evenly distributed.

In summary, clustering-based routing protocols are an efficient and effective approach for routing in sensor cloud models for efficient energy wireless networks. These protocols minimize energy consumption, enhance network scalability and security, and adapt to changes in the network topology. Some commonly used clustering-based routing protocols include LEACH, SEP, and HEED.

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.

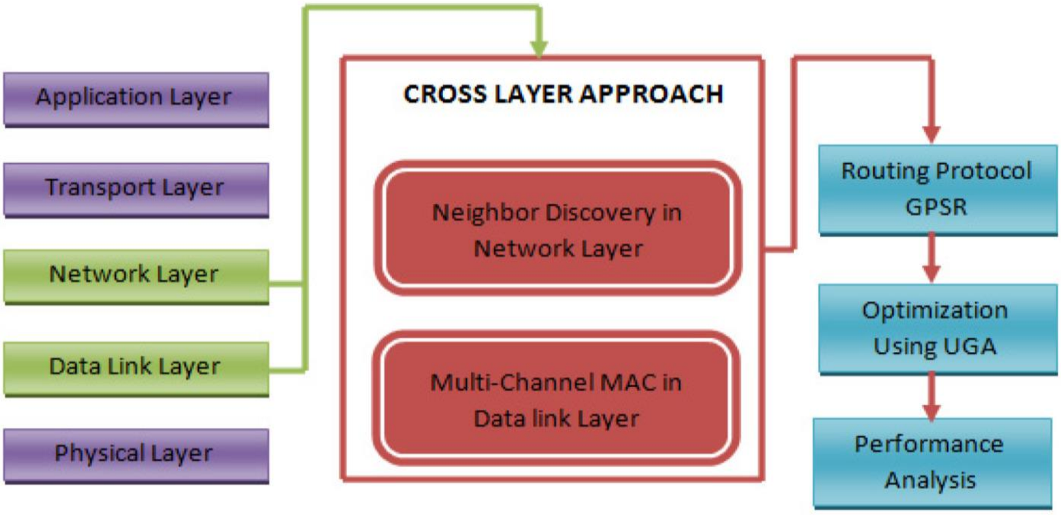


Figure: Cross Layer Transmission

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

- Improved performance: Cross-layer based routing protocols can improve network performance by using information from multiple layers to make routing decisions. This approach can optimize the use of network resources, minimize energy consumption, and reduce packet loss.
- Adaptability: Cross-layer based routing protocols can adapt to changes in the network environment, such as changes in traffic patterns, channel conditions, and energy availability.
- Energy efficiency: Cross-layer based routing protocols can reduce energy consumption by using information about the energy status of nodes to make routing decisions.
- Scalability: Cross-layer based routing protocols can be scaled up to handle a large number of nodes in the network.
- Robustness: Cross-layer based routing protocols can improve the robustness of the network by incorporating information about network topology, energy consumption, and traffic patterns.
- Some of the cross-layer based routing protocols commonly used in sensor cloud models include:
- Energy-Aware Multi-Layered Routing Protocol (EMRP): EMRP is a cross-layer based routing protocol that considers information from multiple layers, including the physical layer, MAC layer, and routing layer, to make routing decisions. The protocol aims to reduce energy consumption by selecting energy-efficient routes.
- Cross-Layered Energy-Efficient Routing Protocol (CLEE): CLEE is a cross-layer based routing protocol that considers the energy status of nodes and channel conditions to make routing decisions. The protocol aims to improve energy efficiency by selecting energy-efficient routes and optimizing the transmission power of nodes.
- Cross-Layered Multipath Routing Protocol (CLMRP): CLMRP is a cross-layer based routing protocol that uses multiple paths for data transmission. The protocol considers information from multiple layers, including the network topology, energy consumption, and link quality, to select the most reliable and energy-efficient paths for data transmission.
- Cross-layer based routing protocols are an effective approach for routing in sensor cloud models for efficient energy wireless networks. These protocols can improve network performance, adaptability, energy efficiency, scalability, and robustness. Some commonly used cross-layer based routing protocols include EMRP, CLEE, and CLRMP.

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.

Network Model

To design an efficient energy wireless network for sensor cloud models, a suitable network model is required. The network model must consider the unique characteristics and requirements of sensor networks, such as limited energy and bandwidth, high mobility, and dynamic topology.

One of the commonly used network models for sensor cloud models is the cluster-based network model. In this model, nodes are grouped into clusters, and each cluster is headed by a cluster head (CH). The CH is responsible for aggregating data from member nodes, processing the data, and transmitting it to the base station or other clusters. The cluster-based network model has several advantages, including reduced energy consumption, efficient use of bandwidth, and improved network scalability.

Another commonly used network model for sensor cloud models is the tree-based network model. In this model, nodes are organized in a tree-like structure, with the base station at the root and the sensor nodes as the leaves. The nodes transmit data to their parent nodes until it reaches the root node. The tree-based network model has several advantages, including reduced energy consumption, efficient use of bandwidth, and improved network scalability.

A hybrid network model that combines the cluster-based and tree-based network models is also commonly used in sensor cloud models. In this model, nodes are grouped into clusters, and each cluster is connected to the base station through a tree-like structure. The hybrid network model has several advantages, including improved network scalability, reduced energy consumption, and efficient use of bandwidth.

In summary, a suitable network model for sensor cloud models must consider the unique characteristics and requirements of sensor networks, such as limited energy and bandwidth, high mobility, and dynamic topology. The cluster-based network model, tree-based network model, and hybrid network model are some of the commonly used network models in sensor cloud models. The selection of a suitable network model depends on the specific requirements of the application and the available resources.

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 8: 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.

Genetic Algorithm and Bacterial Conjugation

In our work, firstly, Genetic Algorithm, and then Bacterial Conjugation is used for clustering sensor nodes. The results of the simulation represent 114 percent growth in accelerating the clustering speed. A recent advance in wireless technologies has led to the development of mobile wireless sensor networks. In addition to mobility of sensors, sensors in the network are low-cost and have a limited amount of battery. With regard to fundamental characteristics of these networks they are more applicable. Among different characteristics of these networks they have many applications, such as: search and rescue operations, health and environmental monitoring and intelligent traffic control systems. According to the application requirements with regard to the act that mobile wireless sensor nodes are energy limited equipment, saving energy is one of the most important issues in the designing of these networks. Beside all of the challenges caused by the mobility of the sensor nodes, we can note the routing and dynamic clustering. Studies show that cluster models, which have adjustable parameters have significant impact in minimizing energy consumption and extend the lifetime of the network. Therefore, the main objective of this research is to present and select the smart way using evolutionary algorithms for clustering in mobile wireless sensor networks for increasing Lifetime of the Network and correct delivery of packets.

MATLAB RESULTS

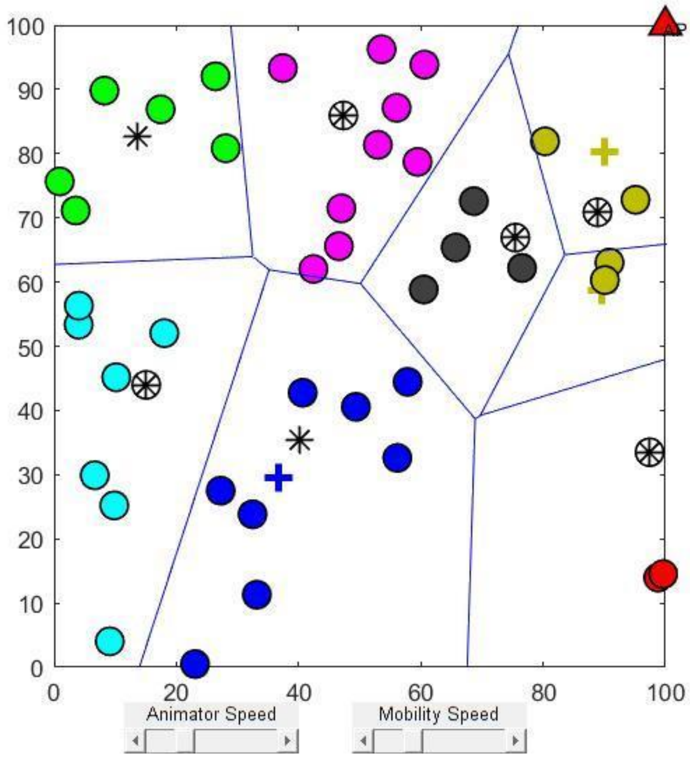
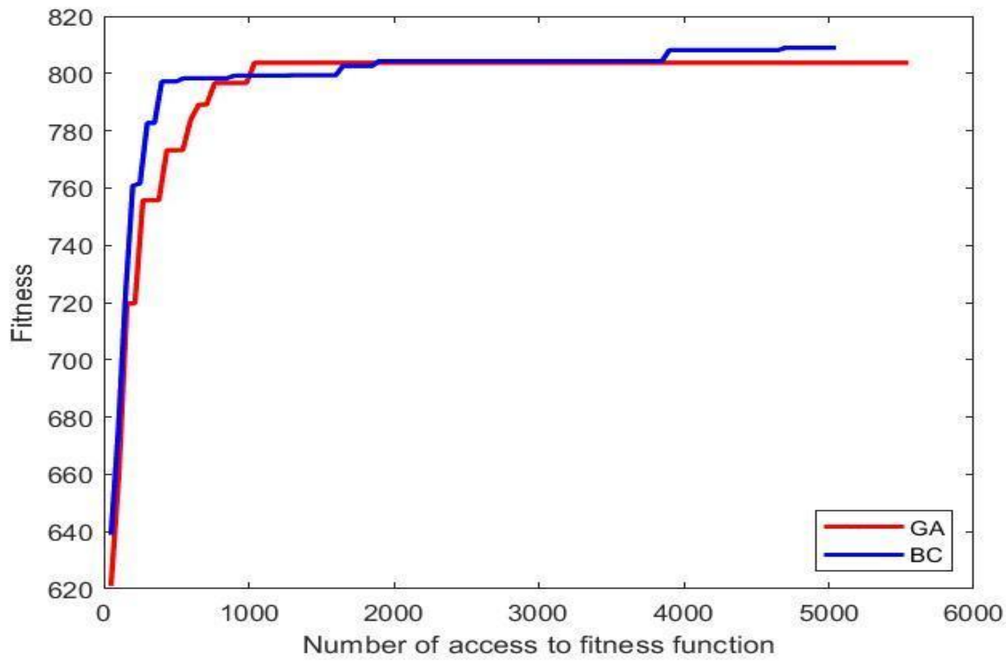


Fig 1 Mobility



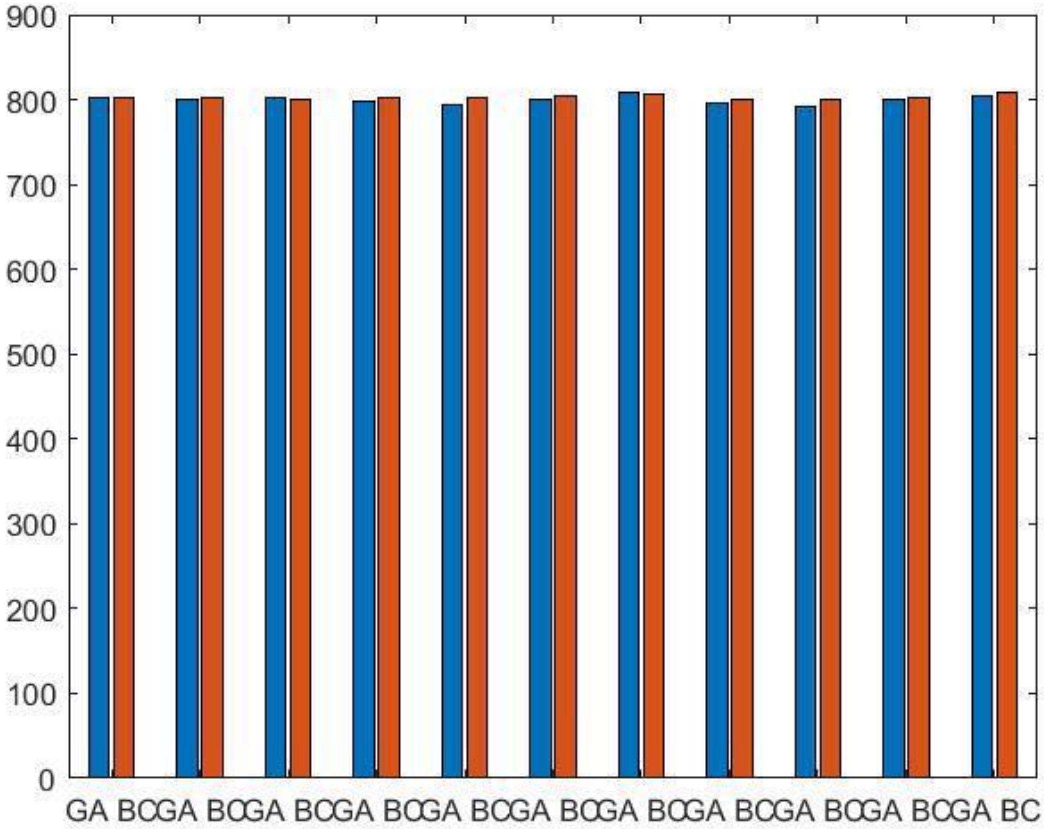


Fig 2 Fitness Function

Clustering is a technique used to group similar data points or nodes in a network to reduce the complexity of data and improve the efficiency of data communication. In mobile wireless sensor networks, clustering is used to improve network scalability and energy efficiency.

● Genetic Algorithm (GA) is a method inspired by the biological evolution process, which is used to solve optimization problems. In clustering, GA can be used to optimize the formation of clusters based on certain objectives such as minimizing energy consumption or maximizing network lifetime.

● Bacterial Conjugation is a process in which genetic information is exchanged between bacteria through direct cell-to-cell contact. In wireless sensor networks, bacterial conjugation can be used as a metaphor to model the information exchange between nodes to support clustering.

Genetic algorithms have been used repeatedly in the past to cluster fixed and mobile wireless sensor nodes [18, 43, 45, 46]. The bacterium that has not been used in this field until now is used in the algorithm to combine the chromosome with the best fit of the donor chromosome and the chromosome with the worst fit of the recipient chromosome. The best and worst fitness values are known during the execution of the algorithm. After the gene transfer stage, the recipient chromosome and the newly created chromosome from the first stage enter the competition stage. The produced chromosome is the output of the bacterial combination algorithm. This algorithm has only one input and its response time is fast, and considering the number of times of referring to the fitness function, it has an optimal response compared to the genetic algorithm in 85% of the cases. The results obtained from the simulation of the presented algorithm and its comparison with the results obtained from the genetic algorithm with the number of 50 identical sensors and fixed parameters of the network in 10 consecutive executions show a growth of 114% in the acceleration of clustering. By changing the number of sensors, an increase of more than 120% can be achieved

CONCLUSION

Genetic Algorithm is a biologically inspired optimization technique that simulates the process of natural selection and genetic recombination to find an optimal solution. The main advantages of GA are its ability to handle large datasets, its ability to avoid local optima, and its ability to work with incomplete information. Bacterial Conjugation is a biologically inspired technique that simulates the process of bacterial conjugation to transfer genetic information from one bacterium to another. In WSNs, BC heads and to transfer information about the study of clustering in mobile wireless sensor networks is a hot topic with a bright future. The creation of more effective and efficient clustering algorithms in such networks can be facilitated by the use of genetic algorithms and bacterial conjugation as optimization strategies.

The employment of genetic algorithms in wireless sensor networks can assist in addressing issues like energy efficiency, load balancing, and network scalability. Genetic algorithms have been extensively employed in many sectors for optimization objectives. The positioning of cluster heads, the size of the clusters, and other network properties can all be optimized through the application of genetic algorithms in clustering.

put the network topology from one node to another. The main advantages of BC are its ability to handle large datasets, its ability to find an optimal solution in a distributed manner, and its ability to maintain network connectivity even when nodes fail. Both GA and BC have been shown to be effective in clustering WSNs, and they are becoming increasingly popular as they provide efficient and scalable solutions to the challenges faced by WSNs. They are also being used in combination with other techniques, such as energy-aware routing algorithms and fault-tolerant protocols, to further enhance the performance and reliability of WSNs. Both GA and BC based clustering algorithms in MWSNs have shown promising results in terms of energy efficiency, load balancing, and fault tolerance. However, there are some differences between these two bio-inspired optimization techniques.

The GA-based clustering algorithms are based on the concept of natural selection and genetic evolution. GA is a population-based optimization technique that uses fitness functions to evaluate the quality of the solutions. GA is suitable for optimizing multiple objectives simultaneously and provides a better trade-off between conflicting objectives. GA-based clustering algorithms are generally computationally expensive due to the large population size and The BC-based clustering algorithms, on the other hand, are based on the bacterial conjugation process, which simulates the exchange of genetic material between bacteria. BC-based algorithms use the concept of a donor bacterium, which shares its genetic material with a recipient bacterium, to optimize the clustering process. BC-based algorithms are generally less computationally expensive compared to GA-based algorithms because they use a smaller population size.

FUTURE SCOPE

The study of clustering in mobile wireless sensor networks is a hot topic with a bright future. The creation of more effective and efficient clustering algorithms in such networks can be facilitated by the use of genetic algorithms and bacterial conjugation as optimization strategies.

The employment of genetic algorithms in wireless sensor networks can assist in addressing issues like energy efficiency, load balancing, and network scalability. Genetic algorithms have been extensively employed in many sectors for optimization objectives. The positioning of cluster heads, the size of the clusters, and other network properties can all be optimized through the application of genetic algorithms in clustering.

Bacterial conjugation, on the other hand, is a process of genetic exchange that occurs between bacteria. This process has been modeled and applied in various fields, including wireless sensor networks, to solve optimization problems. Bacterial conjugation algorithms have been shown to have advantages such as faster convergence, better stability, and lower computational overhead compared to traditional optimization algorithms.

In the future, the combination of genetic algorithms and bacterial conjugation could lead to the development of more sophisticated clustering algorithms that can efficiently handle the dynamic and heterogeneous nature of mobile wireless sensor networks. These algorithms could improve the overall performance of such networks.

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