

# Survey of Recent Energy-Efficient Techniques in Wireless Sensor Networks

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**Abstract-** Wireless sensor networks are gaining a lot of traction in today's IoT-enabled industrial and home applications that use either homogeneous or heterogeneous sensors to collect intent data. Because the application of WSNs is geographically dependent, they are designed to run on self-powered sensor nodes. These nodes must be energy efficient for the network to last as long as possible. Cluster head selection is an important step in a WSN architecture that focuses on reducing network energy usage. It groups sensor nodes in such a way that a complex network cluster is produced, which has a longer life span and uses less power. Because Wireless Sensor Networks (WSNs) are prone to resource constraints, maintaining the network's correct operation is a prerequisite. In this study, we conducted a thorough examination of recent challenges in Wireless Sensor Networks and covered a variety of topics in relation to various scenarios and methodologies. In addition, the study focuses on contemporary techniques to reducing wireless sensor network energy consumption, as well as research into increasing the network lifetime by diverse authors.

**Keywords:** Wireless sensor networks, energy efficient, sensor nodes, network lifetime

## I. INTRODUCTION

Wireless networks are becoming increasingly prevalent in computer networking due to their low cost and ease of implementation. Wireless Sensor Networks (WSNs) are widespread in wireless networks, in which a few sensor nodes are connected to each other and responsible for communication. Sensor nodes send, receive, and sense data, as well as establish connections with neighbouring nodes or sink nodes. To reduce power consumption, these nodes are often battery-powered and fitted with low-performance processors and small memories. A CPU unit, memory chip, power supply, and sensors and actuators make up a standard sensor node.

Many places where a man cannot easily access are covered by Wireless Sensor Networks. WSNs are mostly used to monitor forests, undersea 3-D environments, civil projects, as well as health and military applications. Sensor nodes are powered by batteries, which are non-replaceable and non chargeable. In this situation, energy conservation for each sensor node is critical. Many researchers have developed techniques and protocols to reduce energy consumption to its bare minimum, but there are still many open challenges in developing suitable energy conservation techniques for sensor nodes in Wireless Sensor Networks. The development of Wireless Sensor Networks is a result of research in the area of low-power radio frequency high speed broadband wireless network technology. When there is an emergency, wireless networks have regularly access to the conducting environment issue.

Wireless Sensor Networks (WSNs) are utilised to sense such areas instead because a user is typically unable to collect data in such inaccessible environments. Because there is a finite amount of energy, it is necessary to reduce energy use, which will lengthen the battery's life span. sense such areas instead because a user is typically unable to collect data in such inaccessible environments. Because there is a finite amount of energy, it is necessary to reduce energy use, which will lengthen the battery's lifespan. In this survey, we cope with this lack by providing a high-performance energy efficient technique in WSN. The reminder of this paper is organized as follows. Section II defines energy consumption techniques, the crucial concept behind energy efficient technique. The aim of Section III is to understand the different strategies for extending the network lifetime in WSN. Analyse the challenges in energy efficient techniques in WSN are discussed in Section.

**II. Energy Efficient Techniques in WSN-** The design of systems based on wireless sensor networks must take energy conservation into consideration. Improving the energy efficiency and maximizing the networking lifetime is the major concern for energy efficient techniques in WSN.

**2.1 Energy Consumption using Hierarchical Protocols-** In order to address this, hierarchical protocols (such as the chain-based approach) have been created to lessen network traffic heading into the sink and extend a network's lifespan. In this focus on the Low

**Energy Adaptive Clustering Hierarchy Methodology -LEACH Protocol)** to suggest a fresh approach of choosing Cluster head for reduce energy. The CH nodes are periodically rotated at random using LEACH. These operations are often divided into the setup phase and the steady-state phase. In the Clusters are arranged and CH (Cluster Head) are chosen during setup. In data transmissions to the BS take place during the steady-state phase. CH is responsible for assigning the role to the node. The node getting the value between 0 and 1, if the value less than the threshold value then it becomes the cluster head for the current round. The following equation can be used to get T(n): Where n is the given node, P is the predetermined percentage of CHs (P = 5%), r is the current round, and G the set of nodes that have not been selected as CHs in the last 1/P rounds. Using this threshold, each node will be a CH at some round with in 1/p. After the election of CH nodes, each ordinary node will determine the optimal CH to join in terms of minimum energy required for transmission.

**2.2 Energy Consumption in Integrated WSN-IoT Environment** - Operations Improves energy consumption in integrated WSN- IoT environment operations using a Chaotic Whale Optimization methodology. By considering the layout of IoT devices, the suggested solution creates a cluster-based communication protocol to increase the energy efficiency in WSN-IoT. IoT objects are arranged in a way that is both economical and guarantees that energy efficiency is attained.

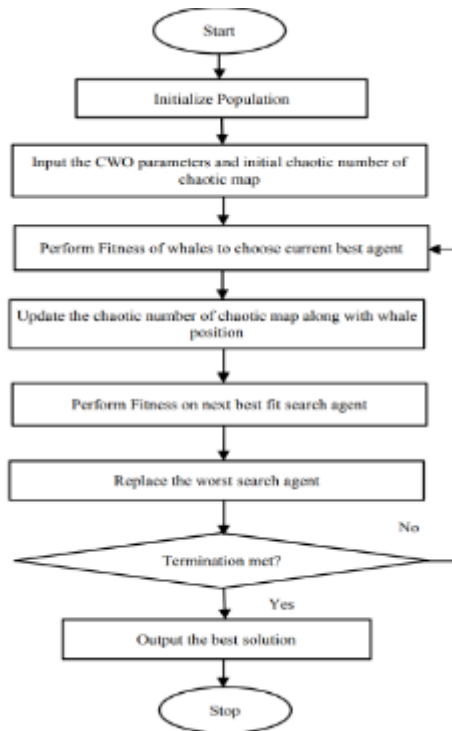


Fig.1 Flow of Chaotic Whale Optimization Process.

The technique works well with static nodes rather than dynamic ones and can be applied to large-scale networks. By minimising the communication distance between sensor nodes when using the cooperative approach, the IoT architecture becomes more robust while also increasing energy efficiency.

**2.3 Energy Saving Techniques for IoT based Heterogeneous-** Wireless nodes Due to the large-scale deployment, there is a greater need for energy. The lifespan of IoT devices is shortened due to the increased communication traffic. To reduce energy usage and increase system longevity, dealing with such devices becomes a crucial task

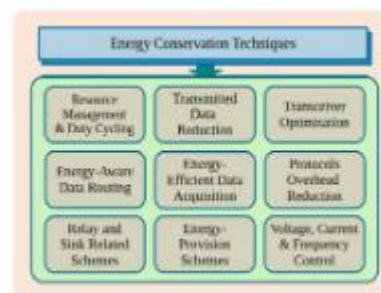


Fig.2 Techniques in IoT based Heterogeneous devices.

Massive amounts of energy have been lost due to the IoT-based wireless systems' rapid expansion and widespread deployment. These methods can contribute to the energy conservation of battery- operated gadgets and increase their lifespan.

**2.4 Energy Efficiency Routing Scheme in WSN -** Large amounts of data packets are sent to the base station with the least amount of delay due to I-DEEC (Improved - Distributed Energy Efficient Clustering) scheme, which lowers power consumption by choosing the best path among the hops. The network's lifetime is increased, and the number of active nodes is increased, which reduces the number of first-round dead nodes. The entire network load is balanced in accordance with ethical standards, extending the life of the network. Data packets are routed to the next hop with a higher remaining power because the first half of the energy function is comparable to the cost of node n. The following is a given of the energy function.

$$E(n) = \text{Max} \left\{ \chi \left( \frac{E_{res}(n)}{E_{ini}(n)} \right) + \psi \left( \frac{P_r(n)}{P_t(n)} \right) + \eta \left( \frac{B_f(n)}{B_{ini}(n)} \right) \right\} + \frac{1}{\text{Min}(hc_n^2)} \quad (17)$$

Where E res(n) denotes the power that is still available and E ini(n) denotes the node n's original power. The number of transmitted packets is Pt(n), the number of received packets is Pr(n), the free buffer is Bf(n), and the initial packet count is Bf(n) .

**2.5 Energy Efficient Enhancement using**

Prediction-Based Scheduling Algorithm Due to the limited battery capacities of sensor nodes in wireless sensor networks, the energy issue is crucial to the effectiveness and longevity of the network. In a load-adaptive beaconing scheduling method is used by the base station to run an updated long short-term memory to regularly estimate the forecast positions of the node. To execute charging activities, a new method termed a predicting-based scheduling algorithm is suggested. In the advised method, which is specific to the current work, it instructs them to seek out the mobile charger and recharge the sensor. The mobile charger will then use a scheduling method to select a suitable node to serve as the charging object. When transferring energy, it is preferable to use a tracking technique based on the Kalman filter to estimate the required charging distance between the destination node and mobile charger. Here, massive data collection in WSNs is used to execute the data gathering and processing. The proposed charging approach will be used to complete the WSN charging operations of nondeterministic mobility nodes.

## II. STRATEGIES OF INCREASING NETWORK LIFETIME IN WSN

One of the most difficult research problems is creating, developing, and implementing energy-efficient procedures for WSNs particularly network lifetime. To increase the network/battery lifetime, researchers proposed new routing protocols or improved current ones to identify more effective solutions.

### 3.1 Lifetime Enhancement using Correlation Model and Node Selection Algorithm –

Before beginning the clustering step, a correlation model is created to filter the sensor nodes based on the correlation value.

```

run CCR() algorithm;
for k = 1: Tot_Correlated_region
    if c(k) > N_min
        select sensor having highest energy in kth correlated region;
        select N_min - 1 distant sensors from the highest energy sensor in kth correlated region;
    else
        all node in c(k) get selected for further clustering process;
    end
end
end
end

```

The network is divided into correlated parts using this correlation model. Correlated regions are those where

numerous sensors have identical copies of the event data because of their near physical proximity. The longevity of the network can be increased by modifying the correlation threshold, according to a study that was done to demonstrate the effect of the correlation threshold value.

### 3.2 Increasing Network Lifetime with Mobile Sink node

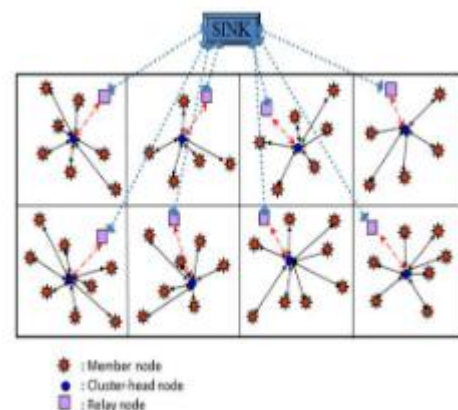
By generating random positions, pick the ideal placement for the mobile sink in relation to the nodes to conserve their power. The search results demonstrate how to represent a network model to lengthen network lifetime. Energy transmission and reception consumption are computed for L-bit packet length as stated in formula 1: Sink gathering and exchanging the data with spring way to the centre of coverage region.

$$E_{TS}(L, d) = \begin{cases} L \cdot E_{elec} + L \cdot \alpha_{fs} \cdot d^n & \text{if } d_i < d_{i+1} \\ L \cdot E_{elec} + L \cdot \alpha_{amp} \cdot d^n & \text{if } d_i \geq d_{i+1} \end{cases} \dots (1)$$

In this equation, E-elec. for the transmitter or receiver stands for electronic energy consumption,  $d_i$  is the distance of a single hop transmission,  $n$  is the number of nodes, and denotes the amplification coefficient for the free space model and the multi route fading model.

### 3.3 Energy Enhancement using two-level

clustering mechanism in IoT based WSN In wireless sensor networks, a novel clustering technique is created with the intention of increasing network longevity through load balancing (WSNs). By electing a new node to a provider, this is accomplished. Certain WSN tasks to reduce energy use and lengthen network lifetime. This node, which is referred to as a relay node, oversees transmitting the forwards the data packets received from the CHs to the central node (sink).



In order to obtain the shortest path to the sink and maximise energy savings in the WSN, the relay node is selected depending on its proximity to the sink. Additionally, the amount of battery power left in the sensor's node battery affects the relay node selection. As a

result, with each role rotation, it saves more energy. When a node's energy drops below a threshold level, its duty is altered. Until all nodes in the cluster have energy that is lower than the threshold value (50 percent) of the original battery energy, the relay rotation process is repeated.

### 3.4 Lifetime Enhancement using Energy Aware Clustering Algorithm with Fuzzy System

Fuzzy and energy-aware clustering algorithms are used to consider the remaining energy. The cluster head in cluster-based wireless sensor networks collects all kinds of data from each node and oversees passing the to the various destination nodes the collected data. It reduces message overhead, latency and boosting the percentage of delivered packets and extending network life.

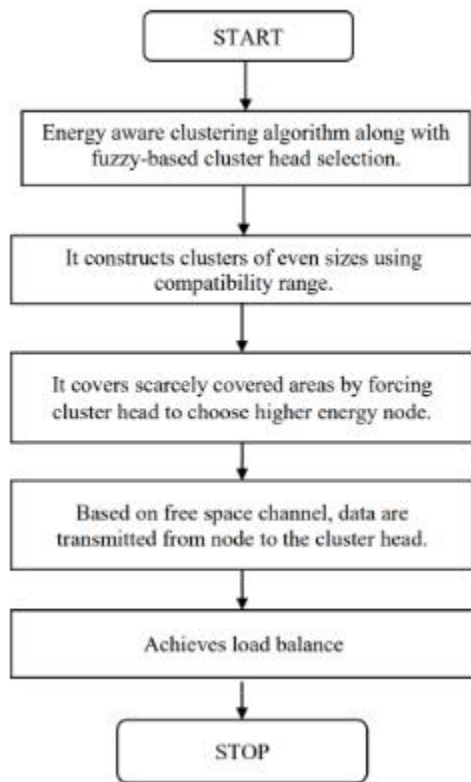


Fig3 Energy Aware Clustering Algorithm with Fuzzy.

The maximum cluster head coverage is taken into consideration while choosing the cluster head nodes. Due to the occurrence of higher energy saving, cluster heads are replaced in the subsequent communication cycle. Each cluster's persisting nodes join the cluster that is closest to them and pass their data to the cluster head node. When the cluster head node sends data to the access point after fusing the data from each individual node, the single communication iteration is finished. Energy consumption is balanced by occasionally switching the cluster head node in order to maintain load balancing among the sensor nodes.

### 3.5 Enhanced Heterogeneous Energy Aware Multi hop Routing Protocol

It is suggested to use the improved Heterogeneous Gateway-based Energy-Aware multi-hop routing protocol (HMGEAR). Use of multi-hop communication techniques across all the deployment of the energy hole elimination technology in various network locations. All these Statics are designed to cut save on energy use and increase network lifespan.

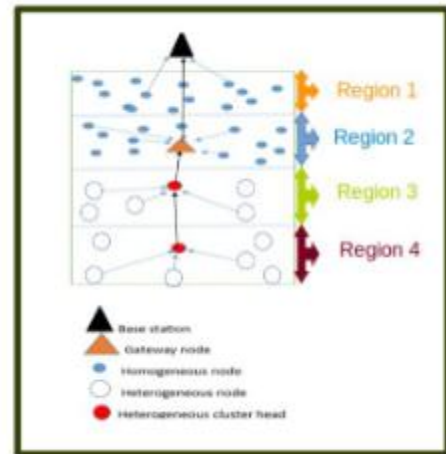


Fig: Gateway based Energy Aware Routing Protocol

The network model shown in Figure is described in the manner that follows. A network it is where BS is the network base station and GW is the network gateway, the expression is  $G(BS, GW, Ho, He, L)$ . The sets of homogeneous nodes (Ho), heterogeneous nodes (He), and lattice nodes (L) are any node in the union  $BS \cup GW \cup Ho \cup He$  of connections linking any of the defined nodes. The network

#### Characteristics are listed below.

Four subnetworks can be created within the network regionally 1, 2, 3, and 4 according to Figure. A node in region 3 is connected to at least one node in region 4, and vice versa. The gateway is linked to the BS and is in region 2. The base station and the gateway are linked. The base station is linked to every node in region 1. Not every node in regions 3 and 4 is linked to the base station.

### 3.6 Cluster Head Selection using Hybrid

Artificial Bee Colony and Firefly Algorithm for Network Lifetime It is suggested to use the Hybrid Modified Artificial Bee Colony and Firefly Algorithm (HMABCFA) - Based Cluster Head Selection to guarantee energy stabilisation, delay minimization, and inter-node distance reduction for extending the lifetime of the network. For the purpose of creating a new position that can replace the position that is not updated during the scout bee phase of ABC (Artificial Bee Colony), HMABCFA incorporates the advantages of the Firefly optimization algorithm. The ABC algorithm's integration of the Firefly optimization algorithm avoids the clustering process' drawbacks of premature convergence, sluggish

convergence, and the potential for getting trapped in the local point of optimality. The improved FFOA algorithm is added to the ABC employee bee and scout bee phases during the cluster head selection process for a better exploitation procedure. In order to improve the exploring process, the ABC's scout bee phase has also been incorporated. In order to establish a better balance between ABC and FOA, they are so integrated. HMABCFA Scheme was crucial in the choice of the cluster head. Methods designed to stabilise energy with the shortest possible inter-node distance and latency must be maintained to keep network lifetime expectations at the anticipated level.

#### IV. CHALLENGES IN WSN

Wireless sensor networks have a lot of potential since they will improve our capacity to see and communicate with the physical world from a distance. Sensors can gather enormous amounts of unknowable data. Where it would be impractical to install data and power cables, sensors can be installed and accessed remotely. We must first address the specific limits of these networks and the ensuing technical problems if we utilise sensor networks to their full potential.

**4.1 Self-Management** - A WSN is made up of a lot of sensor nodes that are typically deployed statically. But WSN topology frequently changes as a result of node failure. Additionally, additional sensor nodes may be repositioned at any time, resulting in a network reorganisation. A sensor network system must therefore be flexible enough to adjust to changing connectivity. The network topology is continuously changed during network operations. Once installed, WSN should be able to function independently and be able to configure networks, adaptation, maintenance, and repair.

##### 4.2 Event Driven Challenge

The WSN's framework ought to be built using event-driven technologies. Priority should be given to the important data over other data. The framework must therefore be able to recognise and promptly report any crucial information.

##### 4.3 Fault Tolerance

The property of fault tolerance states that WSN should continue to function in the event of malfunctioning sensors and dead sensor nodes. In a WSN, sensor nodes begin to malfunction or occasionally fail to transmit accurate data to the following node or sink when their power falls below a predetermined threshold value. Sensor networks are susceptible to power outages, malfunctions, and attacks. The sensors that give false readings as a result of an attack or a change in the environment are said to be defective. These sensors are functional or alive, yet they give inaccurate readings. The network should continue to function and maintain a minimum level of serviceability

under such urgent situations. Sensor nodes continuously lose energy when operating in a WSN.

##### 4.4 Time Synchronisation

Independent operation of sensor nodes allows for time synchronisation. Their local time zones are not in sync with one another. As a result, sensing data will be unclear and ambiguous. Real-time or time accurate operation is required for event detection and time-sensitive applications. For some applications, accuracy takes a backseat to energy efficiency. Therefore, depending on the type of application, it is crucial to select and implement the right time synchronisation algorithm.

##### 4.5 Energy

Key components of monitoring and tracking systems are sensors. Sensor nodes are inexpensive, lightweight, and only have a little amount of electricity and battery. The lifetime of sensors is significantly influenced by energy. Energy is used for network activities including data communications using various communication protocols as well as node actions like sensing and data collection. Because they are so little, batteries frequently need to be changed or recharged. There are several ways to produce energy as well, but none of them can do away with the requirement for energy management. The primary difficulty for WSN is managing finite battery by developing and putting into practise a variety of energy-efficient hardware and software protocols.

##### 4.6 Privacy and Security

Assuring data privacy and inviolability, ensuring authentication to confirm the availability and identity of nodes, and ensuring the resilience of applications exposed to attacks that interrupt network operations are some of the key objectives of security. User privacy and data protection are the most crucial services to offer at the network edge. If an IoT is installed in a home, the usage data that is collected can reveal a lot of personal information. One can easily determine whether the house is empty or not, for instance, by looking at the water or power usage. It is a difficult challenge in this situation to continue providing the service without compromising privacy. Before processing, the data may have some personal information removed, for example, by masking every face in the video. Believe that maintaining computers at the data resource's edge, such as at home, is a worthwhile strategy for maintaining privacy and ensuring data security. Several questions need to be resolved for network privacy and data security, including

- The first is a general understanding of security and privacy. As an illustration, consider the security of Wi-Fi networks. In the 439 million households that use wireless connections, 49% of Wi-Fi networks are unsecured, and 80% of homes have routers with default passwords. 89 percent of public Wi-Fi hotspots are insecure. The end user, service provider, and developers of the system and

applications should all be aware that users' privacy might be compromised at the network edge without their knowledge. For instance, if not adequately protected, IP cameras, health monitors, or even some Wi-Fi enabled toys can be easily connected by others.

- Second- The ownership of the data gathered from items/things/nodes at the network's edge is the second issue. Like smartphone apps, the service provider will retain and analyse the end-user data that things collect. The greatest way to secure privacy would be to leave the data where it is obtained and give the user full ownership of it; nevertheless, the end-user must have control over whether this data is to be utilised by service providers or not. Highly private data may also be destroyed after consent in order to further safeguard user privacy.
- Third, there aren't any reliable tools available to safeguard data security and privacy at the network edge. Due to their severe resource limitations, items may not be covered by the current security measures since they need resources. Furthermore, the network is made vulnerable or insecure by the extremely dynamic environment at its edge. Some systems, such as Open mHealth, are suggested for standardizing and storing health data in order to safeguard privacy, however tools are still needed to manage various data properties for edge computing.

#### 4.7 Deployment

Implementing sensor nodes in practical situations is deployment. Depending on the application and the region's demographics, deployment can be done in a structured or random manner. At difficult-to-reach locations, sensor nodes can be dropped from helicopters. If the deployed sensor nodes are too many, network congestion could result from their numerous efforts at simultaneous transmission. In addition, given that they all detect the same phenomena, all these broadcasts may be redundant. Low data yield or insufficient information will arise from sparse or few sensor nodes that have been placed.

**4.8 Quality of Service** -The ability of a sensor network to satisfy application-specific requirements is measured by QoS [7]. Application-specific and network-specific definitions of QoS are both possible. Network coverage, the ideal number of active sensors, the quality and accuracy of sensor data measurement, latency, and delay are all QoS application-specific characteristics. The term "quality of service" (QoS) network perspective refers to the issue of efficiently controlling the energy and bandwidth while also meeting application needs. The WSN's QoS should permit node addition and deletion. Since the topology of the network is constantly changing and routing information is uncertain, managing QoS parameters for sensor networks is challenging.

## V. CONCLUSION

In WSNs, nodes use energy to sense, process, transmit, and receive viable data; on other occasions, nodes waste

energy by carrying out inefficient tasks, using invalid data, and transmitting duplicate data. Therefore, one of the solutions to the inventive operating of WSNs is energy conservation. A wireless sensor network can last longer thanks to some well-established techniques that reduce the communication distance and energy requirement of the data transmission route. However, it is fair to consider many routing options and use a compound approach when making routing decisions. It is also crucial to carefully consider a variety of nodes and network properties when using an ML-based data routing technique in wireless sensor networks. This survey article offers a thorough analysis for the numerous techniques of energy-efficient and the enhancement of network lifetime in WSN. Utilized are centralised clustering techniques and distributed clustering techniques, which are the two main types of energy-efficient clustering methods. There are a number of lifetime enhancement solutions that have been presented in this survey. This paper also takes the research into challenges in WSN, which helps to design the efficient network WSN.

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