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Research Article

Construction of Carbon Audit and Verification System Framework Based on Intelligent Wireless Sensor Network

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With the large amount of carbon emissions from many enterprises over the years, the global greenhouse effect is getting worse. In order to protect the climate and environment on which we depend, the world is taking active measures to reduce carbon emissions as much as possible. At present, the domestic carbon auditing and verification system is relatively late and immature, and the traditional system efficiency is relatively low. Wireless sensor network (WSN) is a particularly flexible distributed wireless communication network, which can coordinate the perception, processing, transmission, and collection of data of objects perceived within the network until the data content is transmitted to the user terminal. This paper aims to study and design an intelligent network model based on WSN so as to calculate and verify the carbon emissions of enterprises and countries. In this paper, an intelligent WSN model based on ZigBee technology is proposed to build an efficient, low-consumption, and high-precision carbon audit and verification system framework. In this paper, the system framework is referred to as ZWCA for short, that is, the carbon audit and verification system framework of WSN based on ZigBee. In addition, this paper compares the ZWCA framework with the traditional carbon audit and verification system in several groups to analyze the practical feasibility and advantages of the ZWCA framework. The test results show that the ZWCA framework proposed in this paper can audit and verify the carbon emissions of major enterprises very well, and the initial startup power of the ZWCA framework is only 1/2 of the traditional one. At the same time, its actual running power consumption is only 3/4 of that of the traditional audit and verification system framework, and the calculation accuracy is as high as 99%. Moreover, the number of node deaths has decreased, and the system stability has been significantly improved.

1. Introduction

Climate change has become a global concern, and its influence is gradually permeating around us, slowly changing our traditional way of production and life. Today, when people's lifestyle is increasingly dependent on energy, production activities basically depend on fossil energy such as coal and oil. If countries around the world continue to develop as before, it is estimated that the global average temperature in 2050 will be 1.4 to 3 degrees Celsius higher than the average temperature from 1961 to 1990. At that time, there will be a series of serious consequences, such as large edges of icebergs in the North Pole and the South Pole, rising sea level, disappearance of vegetation in cold areas, reduction of cultivated land, and changes in climate and hydrological conditions. Faced with such a difficult situation, human beings must think about how to open a new development model to reduce the impact of energy consumption, pollution, and emissions on our living environment.

In order to cope with the increasingly serious global climate change problem, the United Nations (UN) held a meeting in New York, USA, on May 9, 1992, and formulated the Convention of the Global Conference on Global Climate Change-the United Nations Framework Convention on Climate Change. Subsequently, the UN convened the United Nations Conference on Environment and Development. The convening of the conference provided a new boost to the world's response to climate change and put forward many important suggestions for addressing climate change.

China, as a major carbon emitter, is also an active participant in the international conference on carbon emission reduction. For example, at the 20th Conference of the Parties to the United Nations Framework Convention on Climate Change in 2014, China showed its determination to solve the problem of climate warming. From 2016 to 2020, the total carbon emissions will be controlled within 10 billion tons, and the carbon emissions will reach their peak in 2030. Through the "14th Five-Year Plan," China gradually turned to an absolute reduction of carbon emissions, with a view to reaching the peak of carbon emissions in 2030.

With the increasing awareness of consumers' environmental protection and the spread of environmental protection knowledge, low-carbon footprint products are increasingly favored by consumers [1, 2]. Consumers generally know whether a product is a low-carbon footprint product through a carbon label, and a carbon label audit is inseparable from a carbon audit. Carbon audit is the protector of the low-carbon economy, which has great mission and significance. However, the development of carbon audit in China is relatively late, and the theoretical research is not mature enough. At present, the primary task is to build a full carbon audit system, carry out standardized tests, and improve the design of the carbon audit process.

WSN is a rapidly developing field of science and technology. It not only is highly interdisciplinary but also involves a high degree of knowledge integration and combines a variety of high and new technologies, including sensor technology, embedded computing technology, distributed information processing technology, modern network, and wireless communication technology. WSN is a wireless network system composed of a large number of its own fixed or mobile sensor nodes. Through the mutual detection, processing, collection, coordination, and transmission of object information in the monitored area by various sensor nodes, the information is transmitted to interested users through wireless communication and an organized multihop method. In this way, the monitoring integration from the monitoring site to the remote monitoring center is realized, and the seemingly unrelated physical world, computer world, and human society form a unified whole.

Although there are many studies on carbon audit at present, most of them are still on the list of carbon audit issues. There are few practical solutions for carbon audit, and their macroapplicability is poor. Under this background, according to the characteristics of wireless sensors, it is of great practical significance to construct the system framework of carbon audit and verification system.

The innovation of this paper: (1) This paper analyzes the shortcomings of the current domestic carbon audit and verification system and studies the areas that can be improved. (2) Based on the characteristics of WSN studied in this paper, an intelligent WSN model with high efficiency and low consumption is found. (3) This paper will greatly improve work efficiency by applying the designed WSN model to the carbon audit and verification system. (4) The WSCA framework designed in this paper is tested and compared with the traditional framework, which can better reflect the actual effect of the framework designed in this paper.

2. Related Work

With the development of carbon audit, many scholars have conducted relevant research on it. In the establishment of carbon emissions trading system, an accurate carbon audit is needed to reflect the company's carbon emissions. Zhang et al. refer to the carbon audit theory and DSR (Driving Force-State-Response) model, construct the carbon audit evaluation index system, and analyze the application of this system in Japanese steel enterprises. Zhang 's research results show that the establishment of a carbon audit evaluation index system plays an important role in carbon audit. The system has also improved the carbon audit system and assessment mechanism of enterprises, optimized the process of energy-saving and emission reduction of enterprises, and actively contributed to the low-carbon economy. The investigation also found various problems of carbon audit in iron and steel enterprises: lack of infrastructure, shortage of carbon audit talents and innovation of cleaner production technology, insufficient capital investment, and so on [3]. Today, countries and enterprises are verifying the reduction of carbon emissions. All these countries and enterprises are competing with each other. At present, it is also necessary to ensure the capabilities of third-party certification bodies, a process called authentication. The verification institution shall evaluate the accuracy of emission requirements and ensure that the certification body has the ability to complete this task. The latest history of the compulsory and voluntary system shows that this dual responsibility system can provide assurance to meet the audit requirements. Howard has rich experience in implementing carbon emission reduction plans. The World Bank's carbon price dashboard provides information about existing and new carbon pricing plans, ranking 51st in the world. As a result, Howard A learned some of the most effective experiences and lessons about the carbon audit and verification system framework [4]. Carbon emission limitation is an important means to reduce the greenhouse effect and one of the research hotspots. Because of the high energy consumption, reducing carbon emissions in the process of logistics development plays an important role in developing a low-carbon economy. Yong and Jing established a multilevel logistics network optimization model. The model can be divided into two stages. The first stage is to optimize every network node in the supply chain, and the second stage is to optimize logistics distribution channels. Considering the carbon emission factor and integrating it into the objective function, Yong and Jing used Lingo software to analyze whether the benefit value of carbon emission is considered in the logistics network. The results of these two cases show that the logistics network design considering carbon emissions can reduce logistics more effectively, thus improving the social benefits of logistics [5]. The purpose of the Datt survey is to investigate the impact of legitimacy threats on the incentives for companies to obtain external carbon guarantees. According to the legitimacy theory, the concept of legitimacy in a broad sense is used to discuss social order, norm, or norm system. The narrow concept of legitimacy is used to understand the ruling type of a country or the political order. Generally speaking, legitimacy is people's confirmation and obedience to the dominant position; Datt predicts that if a company is threatened by increased legitimacy, it is likely to get a carbon guarantee. Carbon guarantee is the use of CDP data (i.e., continuous data protection). Traditional data backup solutions focus on the periodic backup of data, so it is always accompanied by backup window, data consistency, and the impact on the production system. Three indicators have been identified to measure the legitimacy threats related to climate change: carbon emission intensity, enterprise scale, and impact. According to a study by Datt, high-emission companies are likely to get independent guarantees, and large companies also show the same trend (because they may face pressure from a large number of stakeholders). According to the survey results of Datt, companies with high carbon emissions pose a greater threat to their legitimacy. Using a carbon guarantee can reduce the legitimacy risk by increasing the credibility of carbon disclosure in stakeholder decision-making. However, this study has some limitations. Datt relies on the CDP report for analysis and focuses on the largest companies in the United States. Caution should be taken when extending the results to voluntary carbon guarantee information disclosed in smaller companies, other countries, or other communication channels. Datt research provides additional insights to better understand the determinants and motivations of carbon assurance. This is helpful for policymakers to formulate carbon assurance policies and measures and in the context of voluntary carbon assurance [6]. Fakhurtdinov et al. compared different gas carburizing methods to ensure the treatment quality by analyzing the applied treatment atmosphere indexes, namely, carbon potential level, its adjustability, and weight transfer and showed the efficiency of vacuum carburizing. A good treatment atmosphere is accompanied by the benefits of automatic treatment equipment, which combines carburizing and dry high-pressure nitrogen curing. Facts have proved that it is advisable to set up a special vacuum equipment factory to upgrade thermal production [7]. Chubchenko and Konopel'Ko considered the main problems and latest achievements in the field of carbon isotope ratio analysis and measurement assurance. It summarizes the existing methods of carbon isotope ratio analysis of gas, liquid, and solid materials. Suggestions on developing new carbon isotope reference gas mixtures in containers, which can be traced back to the international standard VPDB, are provided. Basic error limit is required to establish this authentication [8]. The time synchronization algorithm has greatly improved the connectivity, coverage, reliability, and security of network operation. Hu proposed an energy-saving time synchronization algorithm for deploying underwater WSN (UWSN) to monitor interesting phenomena in the coverage area. Hu introduced a prototype synchronization protocol suitable for UWSN, considering the influence of propagation delay and movement. If the timestamp of the received packet is acceptable, the algorithm does not need time synchronization. In this case, the underwater network will not perform global time synchronization frequently or periodically, which reduces the time for synchronizing clocks between sensor nodes [9]. However, although the above research can promote the carbon audit to a certain extent, it has not been widely used in practice, either because its theory is not complete enough or because the design framework is too complicated and the cost is too high, and the ZWCA framework studied in this paper can avoid these problems [10, 11].

3. Carbon Audit and Verification Methods of Intelligent WSN

3.1. WSN

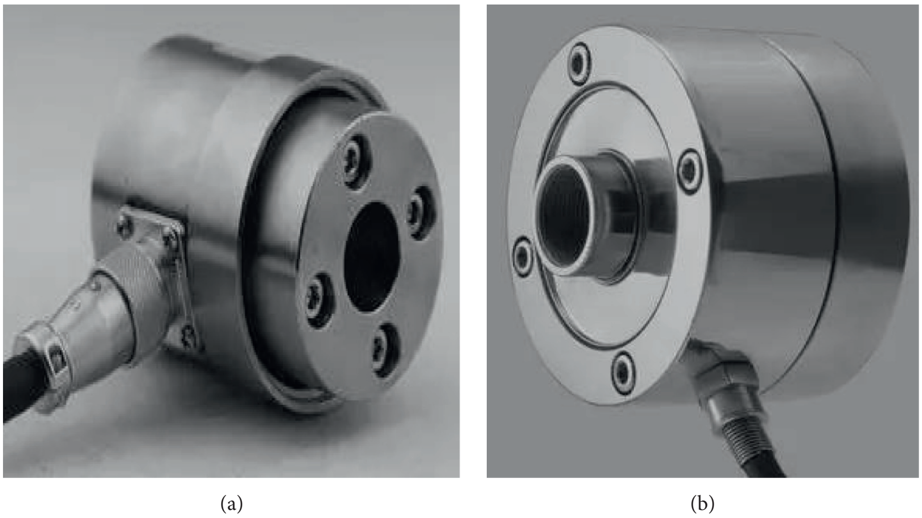
3.1.1. Sensor. Sensor is a kind of sensor that can convert the sensed information into other data output to meet some requirements (information transmission, processing, storage, display, recording, control, etc.). Sensors generally have semiconduct photosensitive element, sound-sensitive element, thermal element, and other components (including sensor, force-sensitive element, magnetic sensor, dew sensor, radiation-sensitive element, color-sensitive element, and taste sensitive element). Figure 1 shows two common sensors [12, 13].

The sensor consists of four parts: sensor element, conversion element, conversion circuit, and auxiliary power supply, as shown in Figure 2.

3.1.2. Wireless Sensor. The component module of the wireless sensor is encapsulated in the housing. During operation, the WSN node is powered by a battery or vibration generator. It integrates randomly distributed micronodes of sensors, data processing units, and communication modules to form a network. Wireless sensors can be generally divided into torque sensors, strain sensors, and vibration sensors according to their sensing principles. Figure 3 shows two commonly used wireless sensors [14].

3.1.3. WSN. The WSN system generally includes sensor nodes, sink nodes, and management nodes. WSN is a self-organizing distributed intelligent network system, which is composed of a large number of small sensor nodes with wireless communication and computing capabilities located in the active area. The distance between sensor nodes is very short, and multihop radio communication is usually used for communication. WSN can run in an independent environment, or it can be connected to the Internet through a gateway to allow users to access it remotely. WSN can monitor, identify, and collect information of different environments or monitored objects in real time through various integrated microsensors, process information through embedded systems, and use multihop relay through random self-organizing wireless communication networks. Figure 4 shows a basic WSN structure [15, 16].

Sensor is a kind of microembedded device with low cost and low power consumption. These limitations inevitably weaken the capability of the processor and reduce the memory capacity. Sensor node is the basic functional unit of WSN. The basic components of sensor node are communication unit, power supply, processing unit, and sensing



(a) (b)

Figure 1: Sensor. (a) Pressure sensor. (b) Gravity sensor.

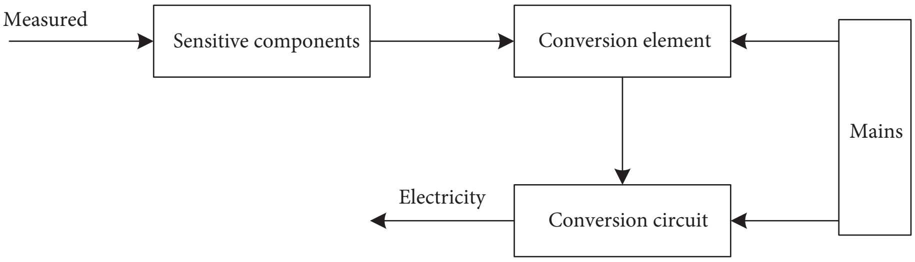
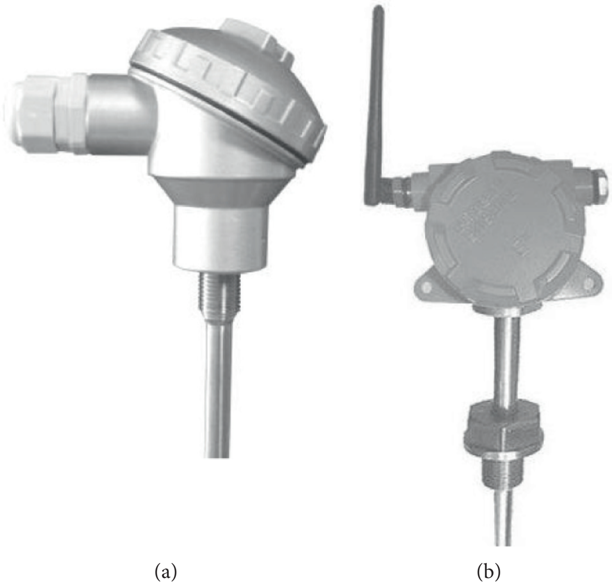


Figure 2: Sensor composition.



(a) (b)

Figure 3: Wireless sensor. (a) Temperature strain sensor. (b) Liquid level torque sensor.

unit. The processing module is the core of sensor node, which is responsible for equipment control, task allocation and scheduling, data integration, and all-node transmission. The node performs preliminary data processing and information fusion on the information collected by itself and the information of other nodes, which is transmitted from neighboring nodes to the base station in the form of relay transmission and received by users through satellite, Internet, and other means. Figure 5 is the composition diagram of WSN nodes [17].

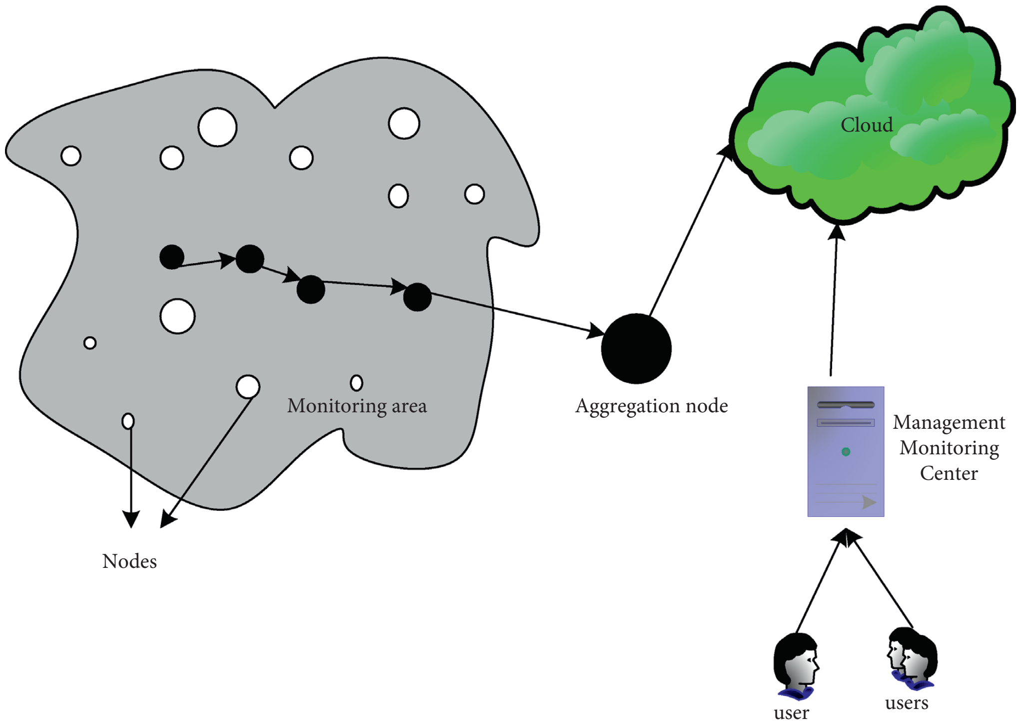


Figure 4: Basic structure of 4.WSN.

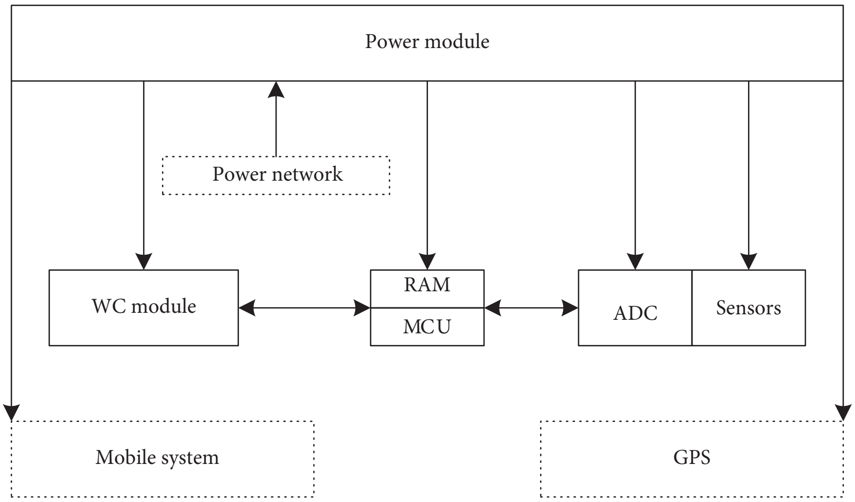


Figure 5: Composition of 5.WSN nodes.

3.2. Intelligent WSN Based on ZigBee. The research on WSN has made great achievements at home and abroad, but there is still room for development. Therefore, this system is doing extensive research on this network. Short-range wireless communication technology is the foundation of WSN. In short, choosing the right communication technology plays an important role in this system. There are many popular short-range wireless communication technologies, such as WiFi, Bluetooth, NFC, UWB, and ZigBee. Each communication technology has its own advantages. WiFi, for example, plays a very powerful role in wireless local area network, and it is widely used, which greatly facilitates people's daily life. It can be found in areas covered by global wireless LAN. However, it is difficult to apply such excellent communication technology to wireless sensor networks, and ZigBee technology is very suitable for wireless sensor networks because of its advantages of large network capacity, low power consumption, and low cost. Table 1 compares the above several common WSN technologies [18].

3.2.1. ZigBee Technology

(1) Concept. ZigBee is a new short-range and low-rate wireless network technology. This is a technical solution between wireless tag technology and Bluetooth technology.

Table 1: Comparison of common WSN technologies.

Genre	WiFi	Bluetooth	UWB	ZigBee
Hz	2.4 G; 5 G	2.4 G	3.1–10.6 G	868 M; 2.4 G
Highest rate	54 Mb/s	1 Mb/s	110 Mb/s	250 Mb/s
Distance	100 m	10 m	10 m	10–100 m
RF channel	14	79	1–15	1–10; 16
Channel bandwidth	22 MHz	1 MHz	500 MHz–7.5 GHz	0.3–0.6 MHz; 2 MHz
IEEE	802.11	802.15.1	802.15.3	802.15.4

It can coordinate the communication among thousands of small sensors. These sensors only need little energy and transmit data between sensors by radio waves, so the communication efficiency between sensors is very high. Finally, these data can be input into a computer for analysis or collected by another wireless technology. At present, ZigBee is a new technology to deploy WSN. The word ZigBee comes from a group of bees. Bees find the location of pollen and inform their companions through ZigBee-shaped dance to exchange information. It can be said that small animals have realized "wireless" communication in an easy and convenient way. People call it a focused wireless network communication technology with low complexity, low cost, low power consumption, and low speed [19].

(2) Composition. The foundation of ZigBee wireless network technology is the IEEE802.15.4 wireless communication protocol. It is a new wireless communication protocol and a low-speed personal area network standard determined by IEEE. This standard defines the physical layer and the media access layer. The complete ZigBee protocol stack consists of multiple layers (including physical layer, medium link layer, network layer, security layer, and application layer), as shown in Figure 6). Figure 6 is a framework diagram of the ZigBee protocol.

(3) Features. The equipment is easy to implement, with high security at all levels, extremely low cost, large network capacity, reliable data transmission, extremely low power consumption, and short distance.

3.2.2. WSN Based on ZigBee Technology

(1) Settings of Nodes. As we know from the front, WSN is mainly a network composed of a large number of sensor nodes, while WSN composed of ZigBee technology focuses on the arrangement of nodes so as to form the optimal network structure to maximize low power consumption, low cost, large capacity, and high security. WSN based on ZigBee technology includes two kinds of nodes and network coordinator (NC), which are network nodes that can communicate with any physical device and protocol nodes that can only communicate with FFD. Network nodes are used for network search, transmission, sending requests to NC, and so on. Protocol nodes are generally in a standby state. NC is mainly used to coordinate the establishment of network, manage nodes, store node information, and improve routing information [20].

(2) Network Topology. WSN topology based on ZigBee technology generally has three types: mesh, tree, and star, as shown in Figure 7. Among them, the biggest advantage of star network topology is its simple structure. Because of its simple structure, fewer upper-layer protocols to be implemented, and less upper-layer routing information, it is very convenient to manage and reduce the equipment procurement cost. The disadvantage is that the network is inflexible, which easily leads to congestion of transmission lines, a sharp increase in data packet loss rate, and poor network reliability and stability. The star network is mainly used to collect small signals, areas where there is more information transmission, and places where there is less information when terminal equipment is unavailable. The advantage of the tree network is that there is little routing information in the upper layer, and it does not need much storage space. At the same time, this new "multihop" function allows developers to use high-power and long-distance wireless communication devices, which can cover a wide range of target areas. The disadvantage is that the routing mechanism is too simple to adapt to the change of external network environment. Mesh network is developed from tree network. Different from the tree network, the unification of information transmission modes in the tree network will lead to the problem of an excessive load because the mesh network is generally composed of several backbone nodes at the same level, which can communicate with each other point to point. Nodes can obtain the most efficient transmission path through a routing algorithm. This significantly reduces the time delay of data transmission on the network and, at the same time, significantly improves the reliability of the network. However, the limitation lies in that the node devices that build the network must have specific computing and storage capabilities, and the running cost of the network is higher than that of the star network and the tree network [21, 22].

(3) Node Calculation. Assuming that the parent node is F, the child node is K, and the depth of the network node is D, then it can be calculated.

The address offset corresponding to a certain depth u is

$$M(u) = \begin{cases} K_m \times \left(D_m - u - 1\right) + 1, \\ \dfrac{\left(K_m + 1\right)^{D_m - u - 1}}{1 - K_m}. \end{cases} \tag{1}$$

The newly added m-th node is k_1, which is a child node, so its address is

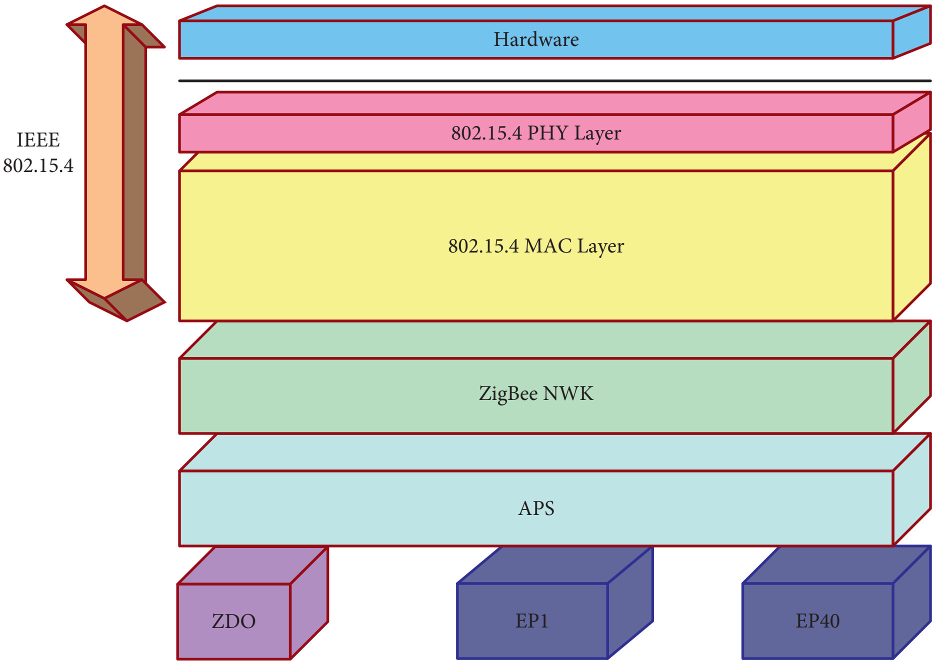


Figure 6: ZigBee protocol framework diagram.

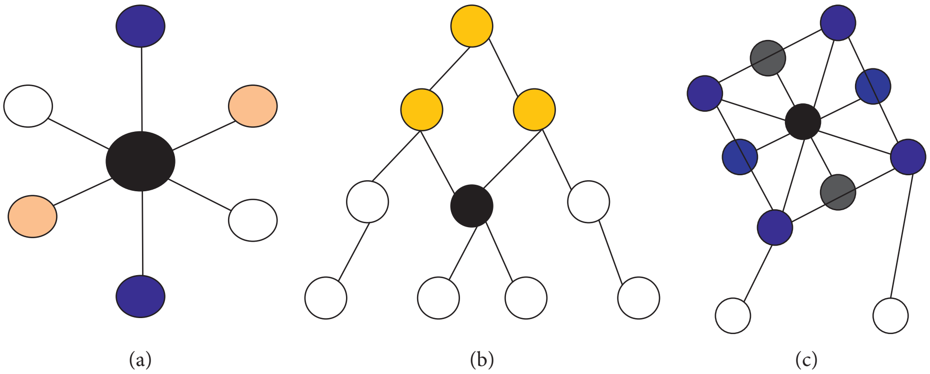

(a) (b) (c)

Figure 7: WSN topology based on ZigBee technology. (a) Star. (b) Tree. (c) Mesh.

$$A_{K_1} = A_F + 1 + M(u) \times (m - 1). \tag{2}$$

The newly added m-th node is k_1, which is not a child node, so its address is

$$A_{K_1} = A_F + M(u) \times (D_m - u - 1) + m. \tag{3}$$

3.3. Carbon Audit and Verification System. At present, the main body of China's carbon audit is government departments, and internal audit and social audit have little effect. However, government audit has shortcomings such as insufficient independence and limited funds, which greatly weakens the role of carbon audit. However, the current carbon audit system does not make full use of strong professional knowledge and high independence of social audit. Therefore, considering the continuous expansion of China's carbon audit business scope, social concern about environmental issues, and the limited power of government carbon audit institutions, China needs to learn from foreign carbon audit methods. Audit institutions actively implement government carbon audit, social audit, and internal audit so that the three types of carbon audit institutions can perform their duties and play a synergistic role in energy conservation and emission reduction [23].

3.3.1. Content of Carbon Audit. Carbon audit standard corresponds to the basis of compiling financial statements in traditional financial statement audit. It is the benchmark used to evaluate and measure the authentication object, and it is an indispensable and important element of the authentication business. In the traditional financial statement audit, appropriate standards need to be relevant, complete, reliable, neutral, and easy to understand. The applicable preparation standard is the financial statement preparation standard stipulated by law, which can be divided into general preparation standard and special preparation standard.

Table 2: Carbon audit status of different businesses.

Attestation business	Traditional financial statement audit	Carbon audit
Audit object information	Financial statements and so on	Carbon emission monitoring plan, greenhouse gas emission report, supplementary data sheet, and so on
Audit standard	"Accounting standards for business enterprises" and so on	"Measures for the management of carbon emissions trading," "calculation methods and guidelines for greenhouse gas emissions in 24 different industries," and so on
Tripartite relationship	Certified public accountant, the management of the audited unit, and the intended user of financial statements	Carbon auditor, the management of the carbon audited entity, and the intended user of the carbon audit report
Audit evidence	Mainly derived from the information obtained through the implementation of audit procedures during the audit process, such as the meeting records of the audited unit	Mainly derived from information obtained through carbon audit procedures, such as a list of corporate emission facilities

General standards mainly refer to the accounting standards of enterprises and related accounting systems, and special-purpose standards may be the requirements of regulatory reports. In the carbon audit business, the accounting standard of carbon emissions is the basis of calculating carbon emissions, which occupies a very important position. Table 2 is a comparison between traditional financial statement audit and carbon audit standards and audit contents [24].

3.3.2. Carbon Audit Procedures. The first is document verification. First of all, a special set-up "carbon audit team" will audit the carbon emission-related documents provided by the audited units. The purpose and content of the document audit include basic information of audited materials, list of carbon emission facilities, list of emission sources, list of monitoring equipment, activity level, carbon emission factors, and other related pieces of information. The second is on-site verification. On-the-spot audit of the specific greenhouse gas emissions of the audited units is conducted with the carbon audit group as the representative. In addition, related personnel visits, site facilities sampling surveys, data visits, personnel interviews, and other ways will be conducted. The third is to prepare a carbon audit report and organize technical verification. According to the legislation on carbon emission verification, a corresponding carbon audit team will be set up. Check the relevant documents of carbon emissions and inspect the actual carbon emissions on the spot. Then calculate the corresponding greenhouse gas emissions, prepare a draft carbon audit report, and submit it to higher audit institutions for review and other purposes [25].

3.3.3. Authentication System. The basis of carbon audit is the accounting, verification, and verification of carbon emissions. Among them, the calculation of carbon emissions is also the calculation method of greenhouse gases. China's greenhouse gas accounting methods are mainly based on the Guidelines for the Preparation of Provincial Greenhouse Gas Inventories (for Trial Implementation) compiled by the National Development and Reform Commission and other specific industry accounting methods. The General Office of the National Development and Reform Commission issued the Notice on Issues Related to Starting the Preparation of Provincial Greenhouse Gas Inventory, requiring all localities to formulate work and preparation plans and organize the preparation of greenhouse gas inventory. The purpose of facilitating greenhouse gas catalog editing is to improve the scientific, standardized, and operability of national greenhouse gas catalog editing. It is also a national greenhouse gas inventory with a consistent format, transparent data, comparable results, and scientific methods. The Edit Inventory task provides strong policy support. Therefore, verification can be supplemented and expanded on the basis of greenhouse gas inventory. Based on this, carbon audit verification is carried out [26].

3.4. Calculation Method of Carbon Audit and Verification for Intelligent WSN

3.4.1. Select Indicators. According to the principle, the construction of a carbon audit evaluation system should establish the evaluation system of standard level, index level, and target level. The selected indicators can be roughly divided into environmental factor indicators, economic factor indicators, calculation factor indicators, and personnel factor indicators. The index weight can be expressed as

$$I_r = \frac{Ex_r}{D_e}, \tag{4}$$

where it indicates the number of indexes considered by experts and the number of valid samples, Ex_r represents the number of indicators considered by experts, and D_e represents the number of valid samples.

The weight of each index is shown in Table 3.

3.4.2. Construct the Index Matrix. After selecting an indicator, create a comparison judgment matrix to facilitate the comparison between elements of each layer. Then, continue the quantitative analysis of each index allocation. Check the consistency of indicators in the judgment matrix.

The matrix formula is as follows:

Table 3: Percentage of each index weight.

Index	Parameter	Weights
Environmental factors index	Ien	1/6
Economic factor index	Iec	1/2
Calculation factor index	Ic	1/6
Human factor index	Im	1/6

$$A = \begin{bmatrix} I_{11} & \cdots & I_{1i} & \cdots & I_{1m} \\ I_{21} & \cdots & I_{2i} & \cdots & I_{2m} \\ I_{31} & \cdots & I_{3i} & \cdots & I_{3m} \\ I_{j1} & \cdots & I_{ij} & \cdots & I_{jm} \end{bmatrix}. \tag{5}$$

The formula for testing consistency is as follows:

$$\begin{aligned} I_s &= \frac{\gamma_{\max} - m}{m - 1}, \\ \gamma_{\max} &= \sum_{1}^{m} \frac{(AI)_i}{mI_r}, \end{aligned} \tag{6}$$

where A represents the characteristic value, m represents the number of indicators, I represents indicators, $\gamma_{\max}$ indicates the eigenvalue, m indicates the number of indicators, and I represents the index.

$$I_s = \frac{I - \overline{I}}{\sigma^2}, \tag{7}$$

where I indicates the standard deviation and σ indicates the standard deviation.

$$I_s = \frac{I}{10^f}, \tag{8}$$

where I is the smallest integer whose absolute value is less than 1. f is the smallest integer satisfying the above fact that the absolute value of I_s is less than 1.

3.4.3. Determine the Scoring Method. Commonly used scoring methods are as follows:

(1) *Additive Scoring Method.* This method is simple to calculate and has a wide range of applications. But the disadvantage is that the calculation sensitivity is not high, and the error is large. The formula is

$$S = \sum_{i=1}^{m} I_i. \tag{9}$$

(2) *Multiplication Scoring Method.* The calculation is simple and clear. But the disadvantage is that the error is also larger. The formula is

$$S = \prod_{i=1}^{m} I_i. \tag{10}$$

(3) *Addition and Multiplication Scoring Method.* The disadvantage is that the calculation is troublesome and subjective. The formula is

$$S = \prod_{k=1}^{m} \left(\sum_{i,j=1}^{m} I_{ij} \right). \tag{11}$$

(4) *Weighted Scoring Method.* The weighting method can be well combined with the analytic hierarchy process (AHP) to calculate, which makes the weighted value can be better applied to the scoring system, and there are fewer unnecessary steps and errors. The formula is as follows:

$$S = \sum_{i=1}^{m} \gamma_i \times I_i, \tag{12}$$

where i represents the matrix weight. γ_i indicates the matrix weight.

(5) *Effective Coefficient Method.* This method can calculate and score the evaluation target from all aspects according to the complexity of the evaluation target, reduce the error of each index value, and objectively reflect the status of the index [27, 28]. The formula is

$$S = \frac{(x_1 - x_2)}{(x_3 - x_1)} \times T + C, \tag{13}$$

where t is the index expansion coefficient and c is a constant.

3.4.4. Build an Evaluation Model. Divide the indicators into positive indicators and negative indicators, and vectorize the indicators. The vectorization formula is

$$V_{ij} = \frac{I_{ij}}{\sqrt{\sum_{i,j=1}^{m} I_{ij}^{2}}}. \tag{14}$$

Because the index is divided into positive and negative, the vector values obtained are divided into positive and negative solutions. The positive solution is r, and the negative solution is e; then

$$\begin{aligned} r_{ij}^{*} &= \begin{cases} \max r_{ij}, r_{ij} > 0, \\ \min r_{ij}, r_{ij} < 0, \end{cases} \\ e_{ij}^{*} &= \begin{cases} \max e_{ij}, e_{ij} < 0, \\ \min e_{ij}, e_{ij} > 0, \end{cases} \end{aligned} \tag{15}$$

where $*$ indicates the ideal solution.

The Euclidean distance of each ideal solution is calculated as follows:

$$\begin{aligned} R_r^{*} &= \sqrt{\left[\sum_{i,j=1}^{m} \left(r_{ij} - \max\left\{ r_{ij} \right\} \right)^2 \right]}, \\ R_e^{*} &= \sqrt{\left[\sum_{i,j=1}^{m} \left(e_{ij} - \min\left\{ e_{ij} \right\} \right)^2 \right]}. \end{aligned} \tag{16}$$

Evaluate each index according to the distance calculated above, and the evaluation index is

$$I_c = \frac{R_e^*}{R_r^* + R_e^*}. \quad (17)$$

4. Design and Experimental Test of ZWCA Framework

4.1. Design of ZWCA Framework

(1) *Module Design of ZigBee*. Chip CC2530 is selected, which can build powerful network nodes with very low total material cost, especially suitable for systems requiring ultralow power consumption. The specific scheme is shown in Figure 8.

(2) *The Choice of the Network Structure of ZWCA*. The network structure selected in this paper is the network structure analyzed earlier. The network structure can reduce the delay of data transmission in the network and greatly improve the reliability of the network.

(3) *ZWCA Framework*. The ZWCA framework designed in this paper is shown in Figure 9. It includes the monitoring system of enterprise carbon index, system fault self-check, and alarm system. Real-time detection of carbon emissions of enterprises and remote viewing of data greatly facilitate the detection efficiency of carbon audit.

(4) *The Characteristics of the ZWCA Framework System*. It includes multinode acquisition and data monitoring, remote data monitoring, real-time early warning, system fault self-checking, fast accounting, high calculation efficiency, and high calculation accuracy.

4.2. Experimental Test. In this experiment, we selected a city with strict carbon emissions to conduct application tests in outdoor and greenhouse, respectively. Set up GPRS module, multiple carbon dioxide sensor nodes, and temperature sensor nodes. We need to be equipped with laptops, multiple sensor nodes, coordinator nodes, serial lines, GPRS modules and simulators, weather stations, and cameras. In addition, a set of traditional carbon monitoring devices is configured for comparative experiments.

Before the test, all the sensors and coordinators are programmed, all the nodes are arranged in every corner and connected into a mesh according to the corresponding program settings, and the weather station is used as control data. Figure 10 shows the connection process of sensor nodes and sensors.

4.3. Experimental Results. After many groups of tests in the experiment, the carbon content obtained is summed and averaged, and the carbon content test comparison is shown in Table 4.

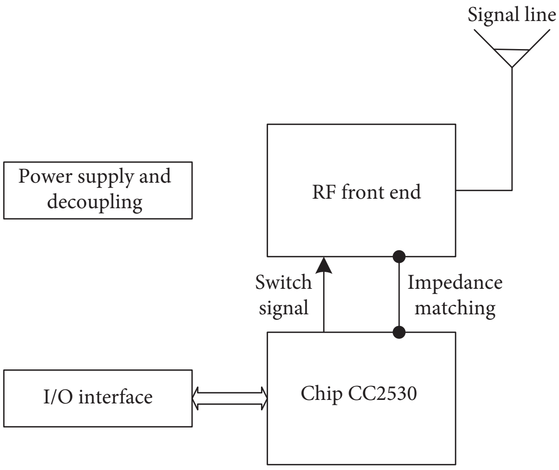


FIGURE 8: Module design of ZigBee.

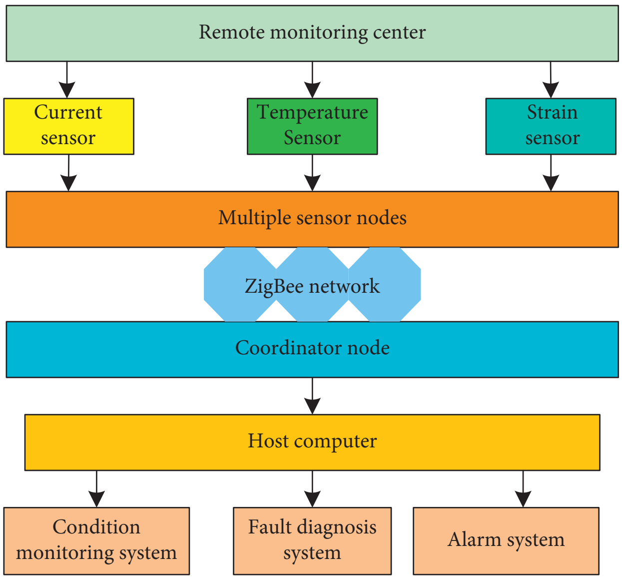
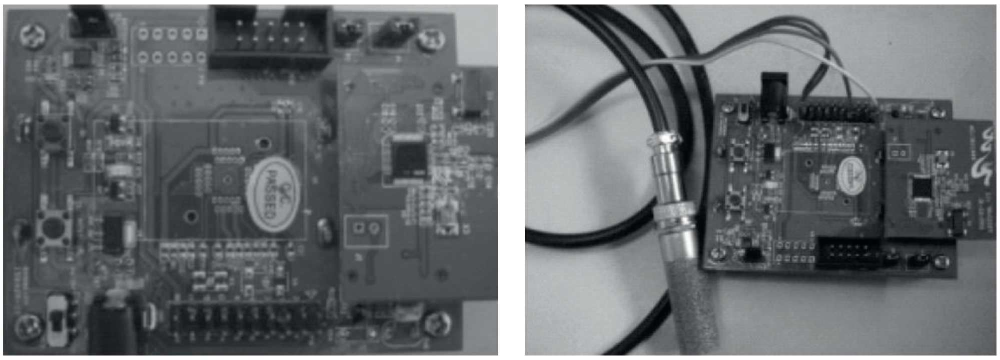


FIGURE 9: ZWCA framework.

It can be seen from Table 4 that the calculation error of carbon content in the ZWCA framework is only 1/4 of that of the traditional framework, and the calculation accuracy is as high as 99%. In addition, in order to compare the advantages of the ZWCA framework, the comparison of network power consumption and the number of node deaths is shown in Figure 11.

As can be seen from Figure 11(a), the overall network power consumption of the ZWCA framework is always lower than that of the traditional framework over time. The initial startup power consumption is only 1/2 of the traditional one, with an average power consumption of 1,200 J per second, while the traditional average power consumption is 1,600 J per second and ZWCA running power consumption is 3/4 of the traditional one. As can be seen from Figure 11(b), the initial number of node deaths of ZWCA is similar to that of traditional ones, but as time goes by, the number of node deaths is much less than that of traditional ones, which also shows that the system stability of ZWCA framework is much higher than that of traditional ones.

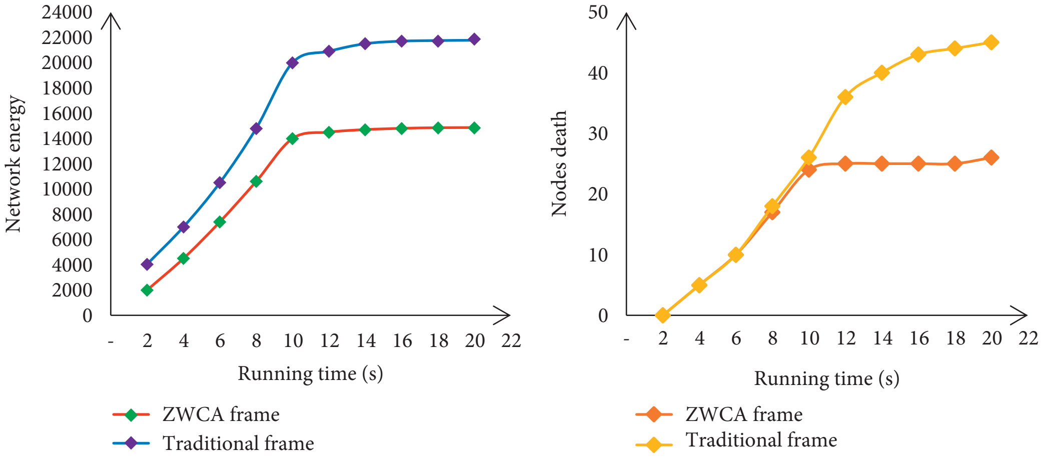


(a) (b)

Figure 10: Connection of nodes. (a) Sensor node. (b) Node connection.

Table 4: Carbon content test comparison.

	Outside greenhouse (ppm)	Inside greenhouse (ppm)	Average error
Weather station	396	1980	0
ZWCA frame	394	1982	±2 ppm
Traditional frame	388	1998	±8 ppm



(a) (b)

Figure 11: Comparison of results.

5. Discussion

Due to the limitation of my knowledge and time, there are still some problems in this paper, and some links need to be improved.

It mainly includes the following issues:

(1) With the update of TI's new protocol stack, it is necessary to continue to develop ZigBee wireless network system, optimize and perfect it, and apply it to various projects.

(2) The network topology is relatively simple. This system adopts a mesh structure, which is simple in structure and convenient in composition, but this network has limitations.

(3) Energy management of nodes: if the sensor nodes of this system are powered by dry batteries, the endurance will be improved.

(4) Network security: this paper does not encrypt or protect the security of the whole network. The information connected to the Internet has great risks and needs to be gradually improved in the future.

(5) Client function: the designed client software is relatively simple and can only do some simple numbers.

(6) Due to the limitation of actual conditions, there is currently no condition for testing the stability and network delay of large-scale network systems in the testing process, and further investigation, experiments, and solutions are needed [29, 30].

Due to the time limit, the long-term (1.4 years) test in low-power applications is inconvenient to test, and further research is needed.

6. Conclusions

Firstly, this paper briefly introduces the related research contents and experimental methods of the paper, then introduces the carbon emission audit problems brought about by the global greenhouse effect in the introduction part, analyzes the current situation and shortcomings of domestic carbon emission research, introduces the characteristics of WSN, and puts forward that it is of great significance to use intelligent WSN to build a carbon audit and verification system. Then, it summarizes the four innovations of this paper, enumerates a large number of cases in related work, analyzes the current research status of many scholars on carbon emission and carbon audit and verification system, and puts forward the advantages of building the WZCA framework in this paper.

In the process of theoretical research, this paper first introduces WSN, which includes sensors, wireless sensors, and their networks, and focuses on sensor nodes. Then, an intelligent WSN based on ZigBee is proposed, in which ZigBee technology is first introduced, and then the intelligent network is described in detail. Finally, the carbon audit and verification system is introduced, including its contents, procedures, and verification methods.

In the process of experimental test, this paper first designed and introduced the WZCA framework. In the experimental test, the weather station was selected as the control group. The WZCA framework was compared with the traditional framework for several groups of experiments, and the average value was obtained. Finally, it was concluded that the system stability of the ZWCA framework was higher than that of the traditional framework, with lower starting power consumption and running power consumption, smaller calculation error, and higher accuracy.

Data Availability

No data were used to support this study.

Conflicts of Interest

There are no potential conflicts of interest in this paper.

Authors' Contributions

All authors have seen the manuscript and approved to submit it to this journal.

References

[1] L. Yin, X. Li, L. Gao, C. Lu, and Z. Zhang, "A novel mathematical model and multi-objective method for the low-carbon flexible job shop scheduling problem," *Sustainable Computing: Informatics and Systems*, vol. 13, no. 3, pp. 15–30, 2017.

[2] S.-B. Tsai and K. Wang, "Using a novel method to evaluate the performance of human resources in green logistics enterprises," *Ecological Chemistry and Engineering S*, vol. 26, no. 4, pp. 629–640, 2019.

[3] Y. Zhang, L. Gu, and X. Guo, "Carbon audit evaluation system and its application in the iron and steel enterprises in China," *Journal of Cleaner Production*, vol. 248, Article ID 119204.1, 2020.

[4] A. Howard, "Verification, accreditation provide assurance," *Environmental Forum*, vol. 35, no. 6, 2018.

[5] Y. Yong and W. Jing, "Study of logistics network optimization model considering carbon emissions," *International journal of systems assurance engineering and management*, vol. 8, no. 2, Article ID S1102, 2017.

[6] R. R. Datt, L. Luo, and Q. Tang, "The impact of legitimacy threat on the choice of external carbon assurance: evidence from the United States," *Accounting Research Journal*, vol. 32, no. 1, 2019.

[7] R. S. Fakhurtdinov, M. Y. Ryzhova, and S. A. Pakhomova, "Advantages and commercial application problems of vacuum carburization," *Polymer Science - Series A D*, vol. 10, no. 1, pp. 79–83, 2017.

[8] Y. K. Chubchenko and L. A. Konopel'ko, "Features of determining the isotope composition of carbon in gaseous, liquid, and solid media," *Measurement Techniques*, vol. 60, no. 6, pp. 638–642, 2017.

[9] R. Hu, "Channel access controlling in wireless sensor network using smart grid system," *Applied Mathematics & Information Sciences*, vol. 6, no. 3, pp. 813–820, 2012.

[10] M. Adil, H. Song, J. Ali et al., "EnhancedAODV: a robust three phase priority-based traffic load balancing scheme for internet of things," *IEEE Internet of Things Journal*, 2021.

[11] O. I. Khalaf and G. M. Abdulsahib, "Frequency estimation by the method of minimum mean squared error and P-value distributed in the wireless sensor network," *Journal of Information Science and Engineering*, vol. 35, no. 5, pp. 1099–1112, 2019.

[12] W.-H. Liao, S.-C. Kuai, and M.-S. Lin, "An energy-efficient sensor deployment scheme for wireless sensor networks using ant colony optimization algorithm," *Wireless Personal Communications*, vol. 82, no. 4, pp. 2135–2153, 2015.

[13] W.-W. Chang, T.-J. Sung, H.-W. Huang et al., "A smart medication system using wireless sensor network technologies," *Sensors & Actuators A Physical*, vol. 172, no. 1, pp. 315–321, 2011.

[14] S. C. Mukhopadhyay and J. A. Jiang, "A sensing approach to fruit-growing," *[Smart Sensors, Measurement and Instrumentation] Wireless Sensor Networks and Ecological Monitoring*, 2013.

[15] P. Brindha and A. Senthilkumar, "Data dependability based bimodal encryption scheme for distributed routing in wireless sensor networks," *Peer-to-Peer Networking and Applications*, vol. 13, no. 4, pp. 1142–1151, 2020.

[16] Z. Chen, A. Liu, Z. Li, Y. J. Choi, H. Sekiya, and J. Li, "Energy-efficient broadcasting scheme for smart industrial wireless sensor networks," *Mobile Information Systems*, vol. 2017, no. 12, 17 pages, Article ID 7538190, 2017.

[17] W. Sun, "Research on the construction of smart tourism system based on wireless sensor network," *Mathematical Problems in Engineering*, vol. 2021, Article ID 9950752, 8 pages, 2021.

[18] P. Evík, Z. Samuel, and M. Hodoň, "Wireless sensor network for smart power metering," *Concurrency: Practice and Experience*, vol. 29, no. 23, Article ID e4247.1, 2017.

[19] S. Kurt, H. U. Yildiz, M. Yigit, B. Tavil, and C. Gungor, "Packet size optimization in wireless sensor networks for smart grid applications," *Industrial Electronics IEEE Transactions on*, vol. 64, no. 3, pp. 2392–2401, 2017.

[20] M. Faheem and V. C. Gungor, “MQRP: mobile sinks-based QoS-aware data gathering protocol for wireless sensor networks-based smart grid applications in the context of industry 4.0-based on internet of things,” *Future Generation Computer Systems*, vol. 82, pp. 358–374, 2017.

[21] J. Wang and C. Yu, “Research and improvement of wireless sensor network secure data aggregation protocol based on SMART,” *International Journal of Wireless Information Networks*, vol. 25, no. 3, pp. 1–9, 2018.

[22] A. G. Soundari and V. L. Jyothi, “Energy efficient machine learning technique for smart data collection in wireless sensor networks,” *Circuits, Systems, and Signal Processing*, vol. 39, no. 2, pp. 1089–1122, 2020.

[23] R. Charles, A. Almasarani, and M. A. Majid, “5G-Wireless sensor networks for smart grid-accelerating technology’s progress and innovation in the kingdom of Saudi arabia,” *Procedia Computer Science*, vol. 182, no. 4, pp. 46–55, 2021.

[24] M. Yigit, P. S. Boluk, and V. C. Gungor, “A new efficient error control algorithm for wireless sensor networks in smart grid,” *Computer Standards & Interfaces*, vol. 63, pp. 27–42, 2019.

[25] V. Bianchi, P. Ciampolini, and I. D. Munari, “RSSI-based indoor localization and identification for ZigBee wireless sensor networks in smart homes,” *IEEE Transactions on Instrumentation and Measurement*, vol. 68, no. 2, pp. 566–575, 2019.

[26] C. K. Ng, C. H. Wu, W. H. Ip, and K. L. Yung, “A smart bat algorithm for wireless sensor network deployment in 3-D environment,” *Communications Letters, IEEE*, vol. 22, no. 10, pp. 2120–2123, 2018.

[27] L. Nassef, R. El-Habshi, and L. Jose, “clustering-based routing for wireless sensor networks in smart grid environment,” *International Journal of Advanced Smart Sensor Network Systems*, vol. 8, pp. 1–14, 2018.

[28] H. M. Jawad, A. M. Jawad, R. Nordin et al., “Accurate empirical path-loss model based on particle swarm optimization for wireless sensor networks in smart agriculture,” *IEEE Sensors Journal*, vol. 20, no. 1, pp. 552–561, 2019.

[29] Y. Saraya, N. Saotome, T. Furukawa et al., “Design and performance of daily quality assurance system for carbon ion therapy at NIRS,” *Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms*, vol. 406, pp. 356–360, 2017.

[30] O. Bjorkqvist, O. Dahlberg, G. Silver, C. Kolitsidas, O. Quevedo-Teruel, and B. L. G. Jonsson, “Wireless sensor network utilizing radio-frequency energy harvesting for smart building applications [education corner],” *IEEE Antennas and Propagation Magazine*, vol. 60, no. 5, pp. 124–136, 2018.