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Cultivation of Creative Ability in the Teaching Reform of Industrial Design Wireless Sensor

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Keywords: Wireless Sensor, Instructional Design, Network Topology, Network Management, LEACH Algorithm, HEED Algorithm

Abstract: Wireless sensor network is a network with limited energy, which can collect network information in time, analyze the current network operation status, and feedback effective information to managers. It can be seen that the practical course of "Sensor Application Technology" has an important position in the course teaching. By introducing the wireless sensor network architecture and Zigbee related knowledge, secondly, the wireless sensor network topology control is studied, the LEACH algorithm and the HEED algorithm are deeply studied, and the load balancing topology control algorithm (LHTCA algorithm) is designed. The statistical calculation results show that the average private packet rate of 20 nodes reaches 26.9%. The algorithm balances the energy consumption of network nodes and helps to improve the network life cycle. Then, the wireless sensor network management system is designed, and the related software and hardware equipment for the system implementation is introduced. Finally, the load balancing topology algorithm designed by the application is applied to the deployment of the management system, and the teaching management system is tested and verified. The test results show that the system can collect and monitor the students' learning status and other related information in real time, so as to effectively realize the problem of combining theory and practice in teaching courses.Through the Internet teaching system, taking wireless data transmission and reception as the research object, after class through the teaching system to communicate with each other to discuss learning and practice experience, to stimulate students' desire to explore and innovate after class.

1. Introduction

Sensor technology is an important technology in the field of information in the modern world, an important link in detection and automatic control, and is widely used in various fields such as industry, agriculture and military. With the rise of Internet of Things technology, wireless sensor technology has become an important driving force for the development of the information technology industry.

Using the integration of online intelligent system resources to establish students' understanding of the general structure of sensor technology, and form a classroom teaching model that combines theory and practice. On the one hand, the experimental platform allows students to familiarize themselves with their sensory elements and follow-up scenarios, building a perceptual understanding of the entire sensor system. On the other hand, due to the simulation experiment, there may be component loss or signal interference on the experimental platform, and the simulation experiment can solve the problem of the uncertainty of the experimental phenomenon.

The teaching design is based on the majority of students, based on the combination of course theory and practical experience, and the interface of the wireless sensor network teaching system is designed to have the characteristics of graphics, allowing operators to have a more realistic and intuitive experience.

2. Related Work

Wireless sensor networks are rapidly gaining popularity due to their wide application in military and commercial applications, which also puts forward higher and more urgent demands for the development of sensor technology. Khan I introduces the basics of WSN virtualization and inspires its relevance through carefully selected scenarios. Existing works are presented in detail and critically assessed using a set of requirements derived from the scenarios. He also reviews related research projects, discusses several research questions, and provides hints on how to address them [1]. Advances in future computing that support emerging sensor applications are becoming increasingly important due to the need to better utilize computing and communication resources and make them energy efficient. Sheng Z proposes a new method to minimize the energy consumption of processing applications in MWSN while meeting certain completion time requirements. Specifically, by introducing the concept of collaboration, logical and related computing tasks can be optimally divided, offloaded, and executed with the help of peer-to-peer sensor nodes. The proposed solution is thus regarded as a joint optimization of computing and network resources [2]. Jian S proposed that in the application of wireless sensor network (WSN), effective estimation of link quality is a fundamental issue to ensure reliable data transmission and the performance of upper-layer network protocols. He proposed a link quality estimation mechanism based on multi-class classification Support Vector Machine (SVM), and established a link quality estimation model based on SVM and decision tree. The model is based on radial basis kernel function and polynomial kernel function respectively. The experimental results show that the model is reasonable. Compared with recently published link quality estimation models, this model can accurately estimate the current link quality with relatively few probe packets, thereby reducing energy consumption [3]. Long J proposes a novel tree-based steering routing scheme to preserve source location privacy, using a hide-and-seek strategy to create steering or decoy routes along the path from the real source to the receiver. He analyzes energy consumption in WSNs, which can provide guidance on the number of diversion routes created in different areas away from sinks. Theoretical and experimental results show that this scheme is very effective in maximizing network lifetime while improving privacy protection [4]. Shim KA provides a deeper understanding of the public key cryptographic primitives in WSN and discusses their main directions and some open research questions that can be further investigated. State-of-the-art software implementation results of public-key cryptographic primitives in terms of execution time, energy consumption, and resource footprint are investigated on constrained wireless devices used in real life on a selection of popular IEEE 802.15.4 compliant WSN hardware platforms [5]. Lee J aims to describe instructional designs for improving students' higher-order thinking skills (HOTS) in learning mathematics, using data collected through focus group discussions and tests. The results show that the developed instructional design is effective in increasing students' enthusiasm for learning mathematics [6]. Nikhilesh S chose a case of anemia based on the modules already covered in the course. Structured exercises are pre-planned for six different concepts that students should have in order to solve the problem. At the station, groups of 41 or 42 were further divided into 6 smaller groups of 7 students each. After practice, students ride to the next practice station, led by another instructor. The effectiveness of the method was assessed by comparing the academic performance of this group with other similar groups in the previous year [7]. During the cluster establishment stage of Song W, adjacent nodes cluster dynamically and randomly generate cluster heads. In the data communication stage, the nodes in the cluster send data to the cluster head, and the cluster head performs data fusion and sends the result to the aggregation node [8]. Tang C proposed a non-uniform partition-based adaptive dual-cluster head (CH) energy-efficient routing algorithm. According to the distance information from the base station (BS) to each sensor node, the network is divided into several uneven partitions, and CH is selected as the main cluster head (PCH) for each partition [9]. These studies are instructive to a certain extent, but the studies are too single and can be further improved.

3. Wireless Sensor Teaching Reform

At present, there are still limitations in the teaching of "Sensor Application Technology", and there is no good connection between theoretical courses and practical courses. Most of the students have problems such as incomprehension in theoretical classes, in practical classes only to connect lines according to the experimental guide, and unable to truly understand and apply sensor technology [10]. There is a phenomenon that theoretical courses focus on the explanation of principle knowledge, while practical courses focus on modular verification experiments.

The teaching goal of the practical teaching system adopts a modular structure, and its structural relationship is shown in Figure 1. Through the experiments and practical training of each module, students can better grasp the ability of computer measurement and control system design and implementation.

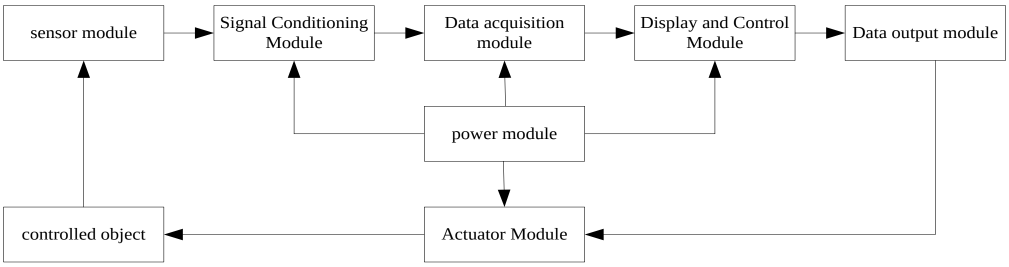

Figure 1. The modular structure of the teaching objectives of the practical teaching system

The sensor network of the teaching system refers to the Open System Interconnection Reference Model (OSI) of the existing network, and designs a research model, as shown in Figure 2. It can be mainly divided into the following layers: one is the physical layer; the second is the data link layer; the third is the network layer; the fourth is the transport layer; the fifth is the application layer.Each practical project has project background, project principle, project steps, key program analysis, program flow chart and after-class thinking. Practical projects are divided into three levels: basic, comprehensive and innovative.

3.1. Topology Control of Wireless Sensor Networks

The wireless broadband communication system is a system that uses radio transmitting and receiving equipment to carry out long-distance one-way communication. The content of communication includes information such as text, voice, image or video, which are sent and received in the form of digital signals. As a two-way wireless communication technology, Zigbee technology mainly has the advantages and characteristics of low cost, low power consumption, simplicity, and short distance. The main application fields are: industrial control, medical equipment control, military, agriculture and other fields.

The ZigBee network mainly uses the distributed allocation mechanism in allocating the network address of the device. After the coordinator is successfully established, the parent device of the device will assign the network address to the device after the device applies to join the network. The maximum depth determines the network address, all parent devices contain the maximum number of child devices, and three represent the maximum number of routing child devices. Through these parameters, it can analyze and calculate the parent device (depth d) router and child device address interval Cskip(d):

$$Cskip(d) = 1 + Cm * (Lm - d - 1) Rm = 1 \quad (1)$$

$$Cskip(d) = 1 + Cm - Rm - Cm * Lm^{(Lm-d-1)} / (1 - Rm) \quad Rm \neq 1 \quad (2)$$

Therefore, under normal circumstances, the network address of the routing node of the parent node does not have continuity, and also in terms of network address, the terminal node of the same parent node has continuity, and this is an objective phenomenon. Specifically, the network address An can be calculated according to the following formula to allocate the network point.

$$An = Ap + Cskip(d) * Rm + n \quad (3)$$

Where: $1 \leq n \leq (Cm-Rm)$, Ap identifies that the parent node has the same network address. From the above analysis, it can be seen that as long as the following three values are determined: one is Rm; the other is Cm; the other is Lm, then in Lm it is equivalent to obtaining the address of the entire network device.

3.2. Analysis of Wireless Data Transmission and Reception Algorithms

(1) LEACH algorithm

According to the idea of LEACH algorithm, nodes are organized into clusters, each cluster has a cluster head node, and other nodes are ordinary nodes. All ordinary nodes can only communicate with the cluster head node of their own cluster, and at the same time, a large amount of node data is collected and aggregated to the sink node after fusing the data [11].

LEACH proposes the concept of "round", which includes the following two stages. The specific algorithm of cluster head election is: each node randomly generates a number in the [0,1] interval. If the number is less than the preset threshold T(n), the node will declare itself as the cluster head node.

$$T_{(n)} = \frac{p}{1 - p * \left[r \bmod (1/p) \right]}, n \in G \quad (4)$$

Among them, p is the probability of becoming a cluster head in a node, r is the current number of rounds, and rmod(1/p) refers to the number of cluster head nodes elected in this round. G refers to a collection of cluster head nodes that have not been selected in each cycle. Its probability can generally be represented by T(n), and T(n) will increase as the number of rounds increases. Assuming that the node has been elected as the cluster head, then T(n) for the remaining rounds can be set equal to zero. In other words, for a node that has not yet been elected as a cluster head, it means that after the next round, it has a better chance of becoming a cluster head, and all nodes will eventually have the opportunity to be elected as a cluster head. The network structure diagram of the LEACH algorithm is shown in Figure 2.

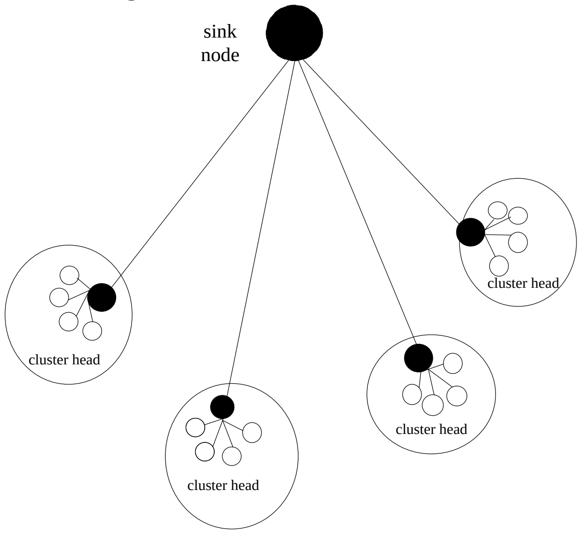

Figure 2. LEACH algorithm network structure diagram

As a classic clustering control topology algorithm, LEACH algorithm has multiple advantages. When allocating resources, using clustering optimization system not only helps to improve power control, but also has the characteristics of longer survival time.

(2) HEED algorithm

The algorithm is formed based on the uneven distribution of cluster heads in the LEACH algorithm [12]. The standard for HEED to judge the communication cost within the cluster is AMPR, that is, the balance of reachable energy. The node can fully combine the initial probabilities in the issue of sending competing messages, which is specifically expressed by CH prob as follows:

$$CH_{prob} = \max(C_{prob} + E_{resident}/E_{\max}, p_{\min}) \tag{5}$$

Based on the basic HEED algorithm of network-wide time synchronization combined with the current residual energy and initial energy, the nodes are divided into various levels. The higher the level of the node, the right to announce the cluster head first, and the lower the level of the node, the cluster head can only be added on the basis of receiving the cluster broadcast [13]. If the remaining energy of the node drops to 1% of the initial energy, it will be disqualified from running for cluster head. Among them, C_{prob} and $\text{p}_{\min}$ are the unified parameters of the entire network, and appropriate parameters can effectively increase the convergence of the algorithm. $E_{resident}/E_{\max}$ represents the percentage of node remaining energy and initialization energy. The HEED algorithm mainly reflects the energy consumption status and the communication cost of the nodes according to the primary and secondary parameters, and uses the basic principle of evenly distributing the consumption to analyze the entire network. This method is used to prolong the network life cycle [14].

(3) LHTCA algorithm

The residual energy is the basis of the main parameters, and it is also the key to the selection of the initial cluster head of the random set. The more residual energy of the node, the greater the probability of being selected as the cluster head. The key to whether a node can be the cluster head node in the end lies in how much energy is left in the node compared to other nodes, that is, the energy of nearby nodes, and the communication cost determines the secondary parameter [15]. The hierarchical topology control algorithm (load balancing) focuses on reducing and balancing the energy consumption of nodes. As shown in Figure 3, at this stage, the wireless transmission energy consumption model is mainly used to study WSN energy consumption and other related conditions.

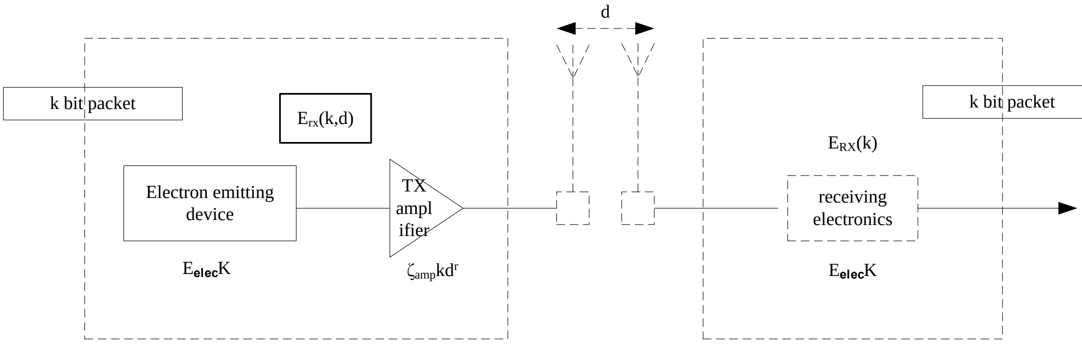

Figure 3. REDM model

The REDM model sets d as the distance between the receiving and transmitting nodes. First of all, it is necessary to assume the threshold d0. The energy consumption of the node to send kbit data packets is:

$$E_{TX}(\mathrm{k},d)=E_{elec}\times \mathrm{k}+\xi_{amp}\times k\times d^{r} \quad (6)$$

The energy consumption for receiving kbit packets is:

$$E_{RX}(\mathrm{k})=E_{elec}\times \mathrm{k} \quad (7)$$

The energy consumption of data fusion is

$$E_{DA}(\mathrm{k},n)=E_{da}\times \mathrm{n}\times k \quad (8)$$

Among them, $E_{elec}=50\mathrm{n}\,J/bit$ is used to describe the energy consumption required to transmit or receive 1 bit. $\xi_{amp}=100p\,J/bit/m^{2}$ can be used to describe the energy consumed by the signal amplifier in sending 1 bit of data to a unit area, which is proportional to the relationship between d and r. Assuming that the transmission time is short, that is, d<d0, r=2, otherwise r=4, EDA represents the energy consumption of n fusion data packets when the packet contains the special number k.

Firstly, by analyzing the LEACH algorithm, and on this basis, a topology control algorithm is proposed. At the same time, the algorithm has periodicity and introduces the probability of "round". The first round mainly includes the following three stages, namely: the first stage of establishment; the second stage of stable data communication; the third stage of evaluation load.

Cluster establishment stage: The selection of cluster heads at this stage should clearly affect the three factors that affect the selection of cluster heads: firstly, the remaining energy of the node; secondly, the distance from the center of the cluster; thirdly, the current actual communication radius. In addition, the node capability function $F_{capability}$ should be fully considered:

$$F_{capability}=E_{resident}*r_{1}+(1/D)*r_{2}+R*r_{3}\ (r_{1}+r_{2}+r_{3}=1 and r_{1}>r_{2}>r_{3}) \quad (9)$$

D is the distance, which is used to describe the distance between the cluster center and the node. Here, it is assumed that the location of the network node has been determined by the positioning algorithm. E_{resident} is used to describe the remaining energy of the node; R represents the radius of the node's current communication, that is, the distance of the node's transmission of information under the current transmit power. r_1、r_2、r_3 is used to refer to the proportion of each part, and the sum of the three is exactly equal to 1. It is worth mentioning that each proportion needs to be set in advance.

Analyzing the cluster head node needs to consume more energy than other nodes, so in the whole function, the remaining energy usually occupies a higher proportion. Combined with the REDM model, considering the central position of the cluster head section of the entire cluster center, it is necessary to determine the second parameter representing the node capability, that is, the cluster center and the node distance [16].Data communication stage: The hierarchical topology control algorithm of load balancing in this stage is basically the same as the LEACH algorithm [17]. After the network builds a cluster, it enters a relatively stable data communication stage.

Load evaluation stage: The hierarchical topology control algorithm of load balancing is based on the LEACH algorithm, and has been improved so that all nodes have the opportunity to serve as cluster heads. This method can balance consumption and reduce energy waste [18]. The above analysis needs to involve a problem, how to judge the load capacity of the cluster head node. This calculation shows the introduction of the load evaluation function method:

$$F_{\mathrm{load}} = E_{resident} * t_1 + (1/D) * t_2 \ (t_1 + t_2 = 1 and t_1 > t_2) \quad (10)$$

Among them, D represents the distance between the node and the center of the cluster, and $E_{resident}$ represents the remaining energy of the node; F_{load} has a load threshold $F_{\mathrm{load}0}$ and t_1、t_2 that need to be set in advance according to the actual situation. After calculating the load F_{load} of the cluster head in combination with the formula, $F_{\mathrm{load}} < F_{\mathrm{load}0}$ judges the load. The simulation model and parameter setting use Matlab software to simulate the network, and analyze and compare the HEED, LEACH and LHTCA algorithms in terms of the overall residual energy of the network and the number of surviving nodes.

Setting the area of 100M*100M wireless sensor network model, and distribute 100 nodes in the area, these nodes are randomly generated. In order to make the results more realistic, the experiment was repeated 400 times, and finally all the collected results were averaged to obtain the final data. After analysis and comparison, the corresponding conclusions are drawn. The simulation parameters are set as shown in Table 1.

Table 1. Settings of simulation parameters

The name of the parameter	Set the value of the parameter
The number of nodes	100
Power consumption of the transmission amplifier	100m*100m
Packet size	10pj/bit/m2
Data processing consumes energy	200b
Energy consumption for sending and receiving data	50nj/bit

(4) Result analysis

According to the simulation scene, in a square area with base station coordinates of (50,175), the size of the area is 100M*100M, in which 100 nodes are randomly distributed, and the initial energy of each node is 2J. The life cycle is shown in Figure 4. When a takes different values, the life cycle of the LHTCA algorithm is much higher than that of the LEACH algorithm.

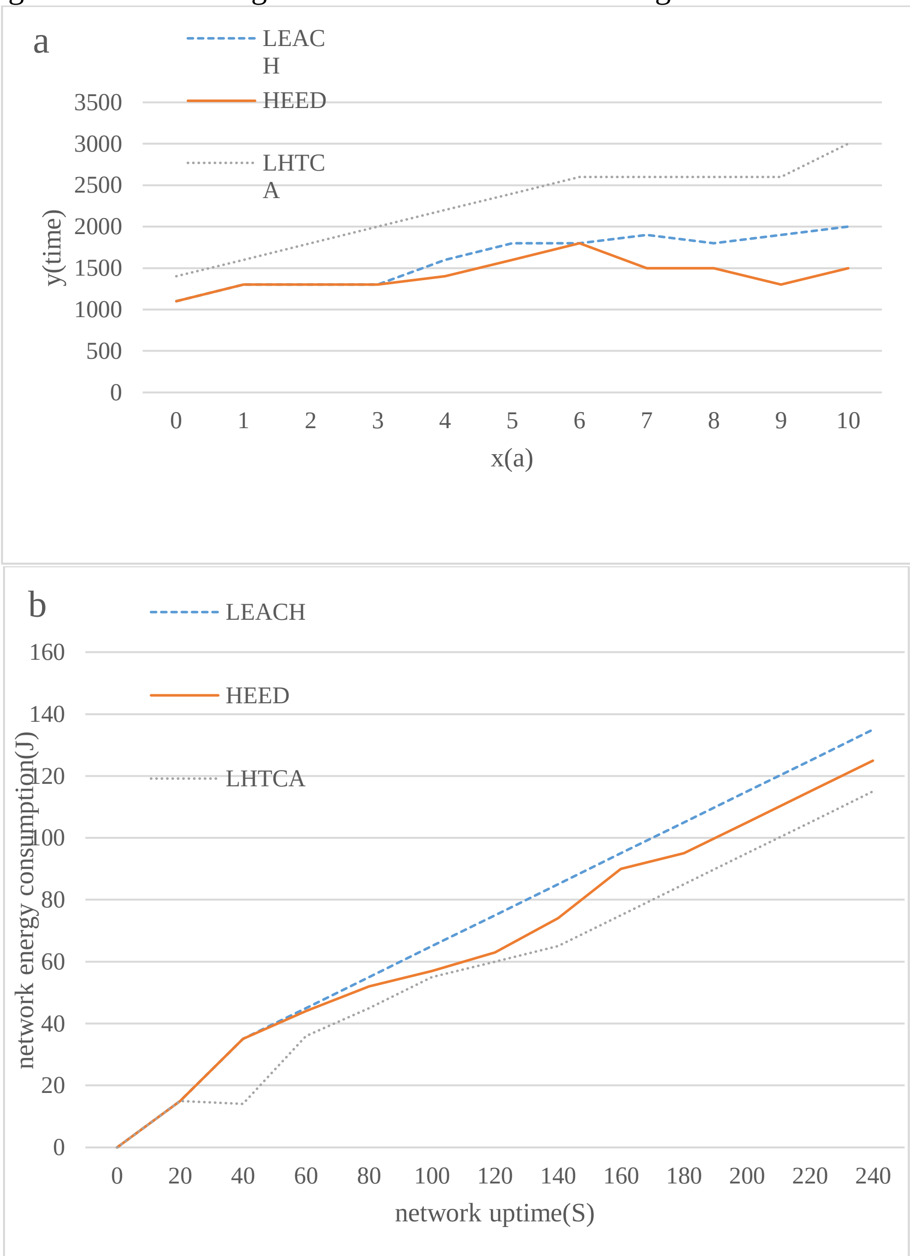

Figure 4. Life cycle comparison diagram and total WSN energy consumption

The energy consumed by the network can be seen from Figure 4. In the first 25 seconds of the network running, the network energy consumption of the three algorithms is not very different. However, from 25 seconds to 300 seconds, compared with the LEACH algorithm and the HEED algorithm, the LHTCA algorithm has a more stable curve change, and the network energy consumption of the LHTCA algorithm is far less than the energy consumption of the other two algorithms. The resource utilization of the network system is improved, which indicates that the LHTCA algorithm has higher performance, which is in line with the purpose of the expected improvement.

3.3. Anti-jamming Attack Methods of Industrial Wireless Sensors

(1) Binary error control coding

The segment of the data sequence in binary error control coding is called codeword, and the whole data is called code. The coding can detect or correct errors mainly because there is a big difference between the codewords [19]. Let the symbol $\sum^{j}(j \geq 1)$ represent the set space composed of j codewords, j is the code length, and the object code u is represented as:

$$u=(u_{1,}\Lambda ,u_{i,}\Lambda ,u_{k}) \in \sum^{k} \quad (11)$$

The cipher code v is expressed as

$$v=(v_{1,}\Lambda ,v_{i,}\Lambda ,v_{n}) \in \sum^{n} \quad (12)$$

In the formula, u_i represents the ith codeword of the object code, and v_i represents the ith codeword of the cipher code. The object code u is converted into the cipher code v by the q-ary real-time encoding function, which can be recorded as:

$$v=(u)_q \quad (13)$$

Let H (x, y) be expressed as the Hamming distance between the code words v_i and $v_i(v_i, v_j \in \sum^{n}(j \geq 1))$, and the minimum distance of the cipher code, that is, the code distance is:

$$d=H(v)^{def}=_{x,y \in C; x \neq y}^{\min}\{H(x,y)\} \quad (14)$$

From the above, it can be known that the code length of the cipher code v is n, the code length of the object code u is k, and the minimum distance of the cipher code is $d=H(v)^{def}$. The hexadecimal number of the real-time encoding scheme function for converting object code into cipher code is q, so the final code r format composed of cipher code code length, object code code length and minimum distance can be recorded as:

$$r=(u)_q/(n,k,d) \quad (15)$$

When q is taken as 2, the error coding is called binary error control coding. The specific communication process of UDSSS can be seen through Figure 5.

(2) Binary error control decoding

Extracting the cipher code $v=(u)_2$ in the final code $r=(u)_2|(n,k,d)$, and convert the encoded cipher code v into the object code u through the binary real-time decoding scheme function, namely

$$u=(v)_{\bar{2}} \quad (16)$$

If the error bits of the received signal are less than half of the code distance, the receiving end can always correctly restore the sent codeword, thereby correctly restoring the sent information, that is, the final code $r=(u)_2|(n,k,d)$ can control the $(d-1)/2$-bit error.

(3) Normal communication stage

The sending node v_A selects a spreading sequence code c_i from the set C of spreading sequence codes at random. After the sending node vA generates the original data M at the application layer, it performs a series of UDSSS encapsulation processing at the data link layer. First, add the signature authentication information to M to obtain the data packet De. The format of the data packet De is as follows:

$$D_e = M|SKA(M) \tag{17}$$

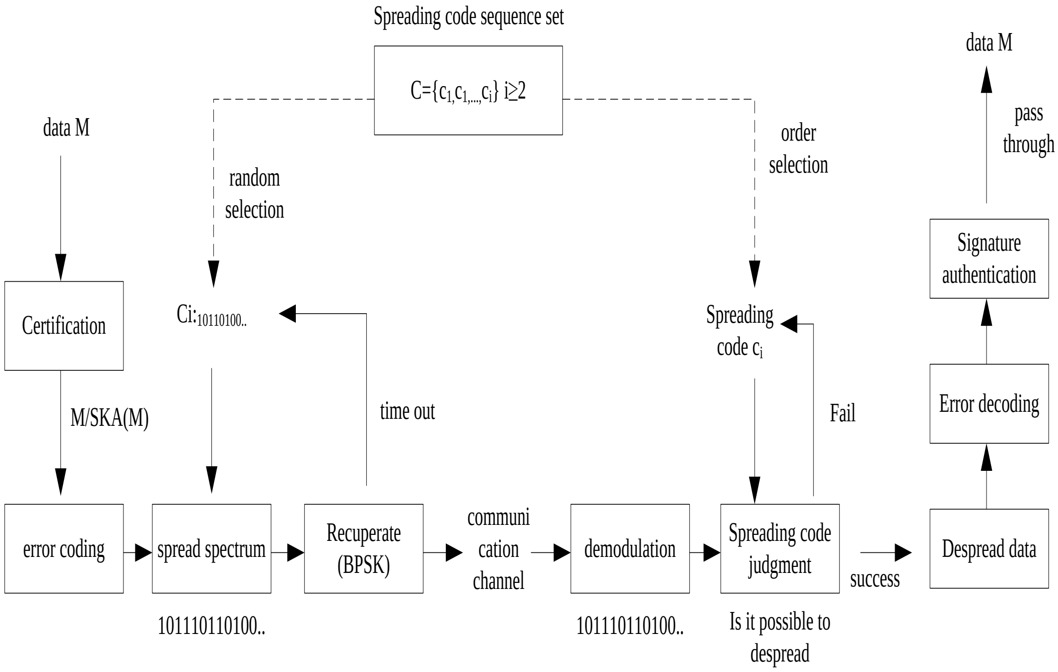

Figure 5. UDSSS communication process

In the formula, SKA(M) represents the private key added to the data M. Then the sending node v_A performs binary error control encoding on the data packet D_e to obtain the data packet D_1. At this time, the data packet format of D_1 is as follows:

$$D_1 = (D_e)_2|(n_e, k_e, d_e)|SKA(M) \tag{18}$$

In the formula, n_e represents the code length of the cipher code converted from the object code, k_e is the code length of the object code, and d_e represents the minimum distance of the cipher code.

The sending node v_A uses the spread spectrum sequence c_i to perform sequence spread spectrum processing on the encoded data packets, that is, the spread spectrum sequence code and the communication data packet sequence perform a modulo two operation. Then, at the modulation end of the sending node, the data packets after the spread spectrum are modulated by BPSK, and finally the modulated data packets are put into the physical layer data packet queue buffer, waiting to be transmitted in the FHSS communication mode.

In the FHSS communication mode, the data packets of the sending node vA are transmitted to the receiving node vB on the real physical channel, and the real physical channel communicated is:

$$C_A = S_{CH}[(N_{TS} + O_C)\%N_C] \tag{19}$$

In the formula, S_{CH} is the frequency hopping sequence composed of active channels, N_{TS} is the absolute time slot number, O_C is the channel offset, N_C is the number of active channels, and O_C and N_C are fixed after the formation of the industrial wireless sensor network.

After receiving the data packet in the real physical channel, the receiving node v_B needs to perform a series of processing to obtain the data M[20]. First, the demodulation terminal of the receiving node v_B performs BPSK demodulation on the received data packet, and then the receiving node v_B continuously selects the spreading code c_i from the spreading sequence code set C in sequence. Determining whether the spread spectrum sequence code c_i can despread the data packet, and if so, use the matching spread spectrum sequence code c_i to despread the data packet to obtain the data packet, which can be expressed as:

$$D_1 = (D_e)_2 | (n_e, k_e, d_e) | SKA(M) \quad (20)$$

The receiving node B performs error decoding on the data packet 1 to obtain the data packet, the format is as follows $D_e = M|SKA(M)$, extracts the SKA (M) in d_e for signature authentication, and obtains the data M if the verification is passed, otherwise discards the data packet.

4. Design and Test of Teaching System

Taking wireless data transmission and reception as an example, many people are not unfamiliar with the transmission and reception of data, but how to realize this process, what principles need to be used, the theoretical knowledge can be found on the Internet, but it is estimated that everyone can operate it. It will feel very complicated, which is the defect of traditional education. Traditional education lacks teacher training for innovative research and development capabilities. The teaching management system can improve the learning and communication among teachers, help to improve the teaching level of teachers, achieve teaching innovation, and create a good teaching atmosphere for students. Due to the gap between theoretical teaching and time teaching, the teaching management system can well record the operation process of students' projects and discuss with each other between classroom teachers and students, which helps to deepen students' learning impression and improve their practical ability. Stimulate students' interest in learning. Through the teaching management system, schools and related professionals can also participate in mutual learning, discussion and resource sharing.

4.1. Software Framework Design

The geographical location of WSN management software in the whole network is shown in Figure 6. Among them, the client can directly interact with user information, and has the function of displaying and configuring tasks; the server is responsible for collecting and processing data in the network management software [21]. The network management software will not affect the actual application of WSN, it can be completely independent of the application system, but directly read the required data from the base station.

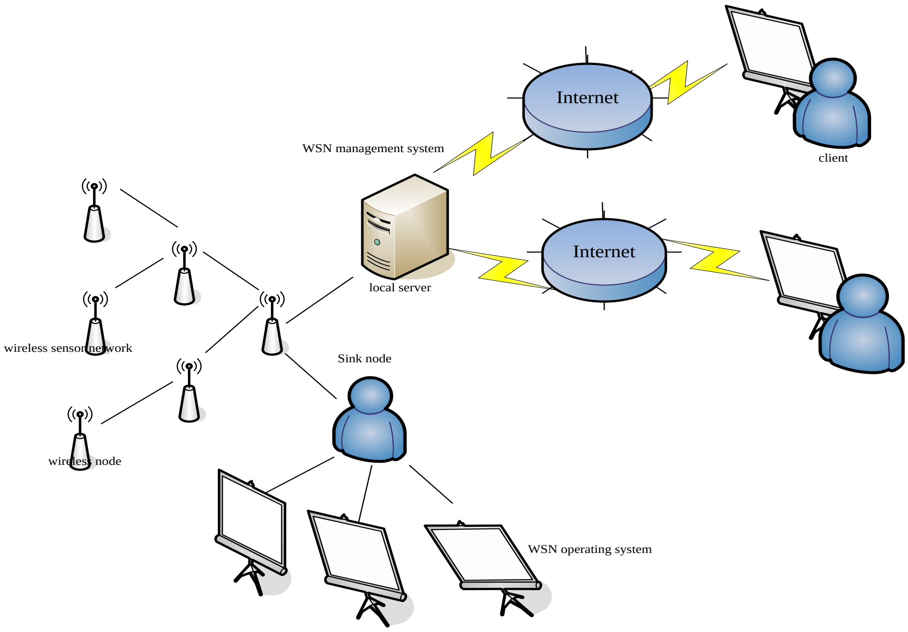

Figure 6. Schematic diagram of the location of the WSN management system

The teaching information management system is mainly composed of the functional modules in Figure 7. After logging in to the system correctly, it can perform corresponding operations according to different roles and permissions. The administrator user has all the rights of the system, and can manage and operate functions such as users, courses, test question banks, test arrangements, automatic test grouping, and scores in the system. The example of the whole system function part is shown in Figure 7.

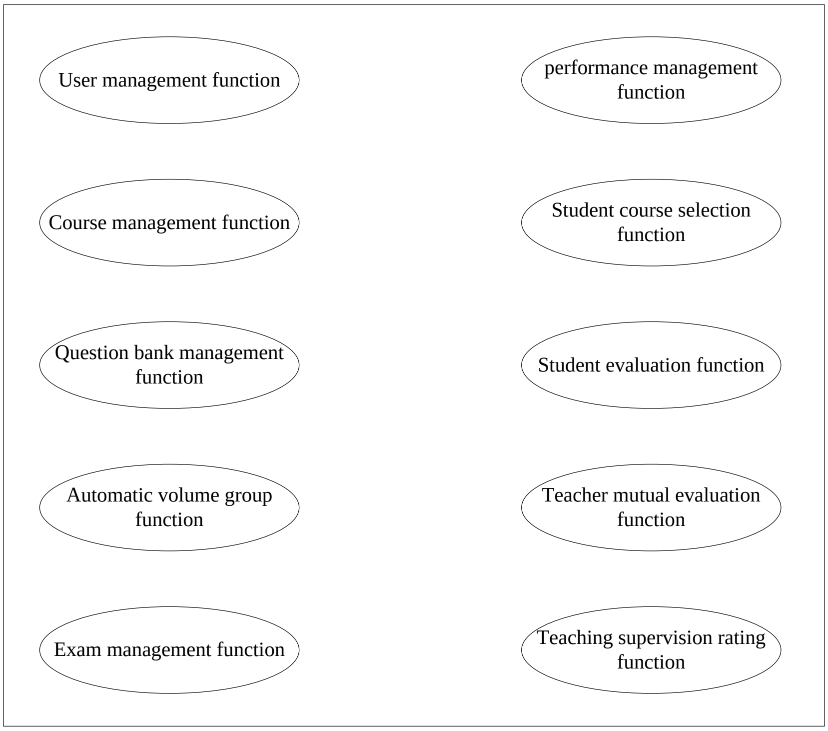

Figure 7. System functional use case diagram

The overall system is divided into modular development, which reduces the coupling between modules to the greatest extent, which is conducive to user authority control, facilitates system development, and is also easy for later operation and maintenance of the system and system upgrade from a long-term perspective [22]. In terms of user experience, the user experience is improved, the operation is more convenient, and the overall user experience of the system is improved. The system flow is shown in Figure 8.

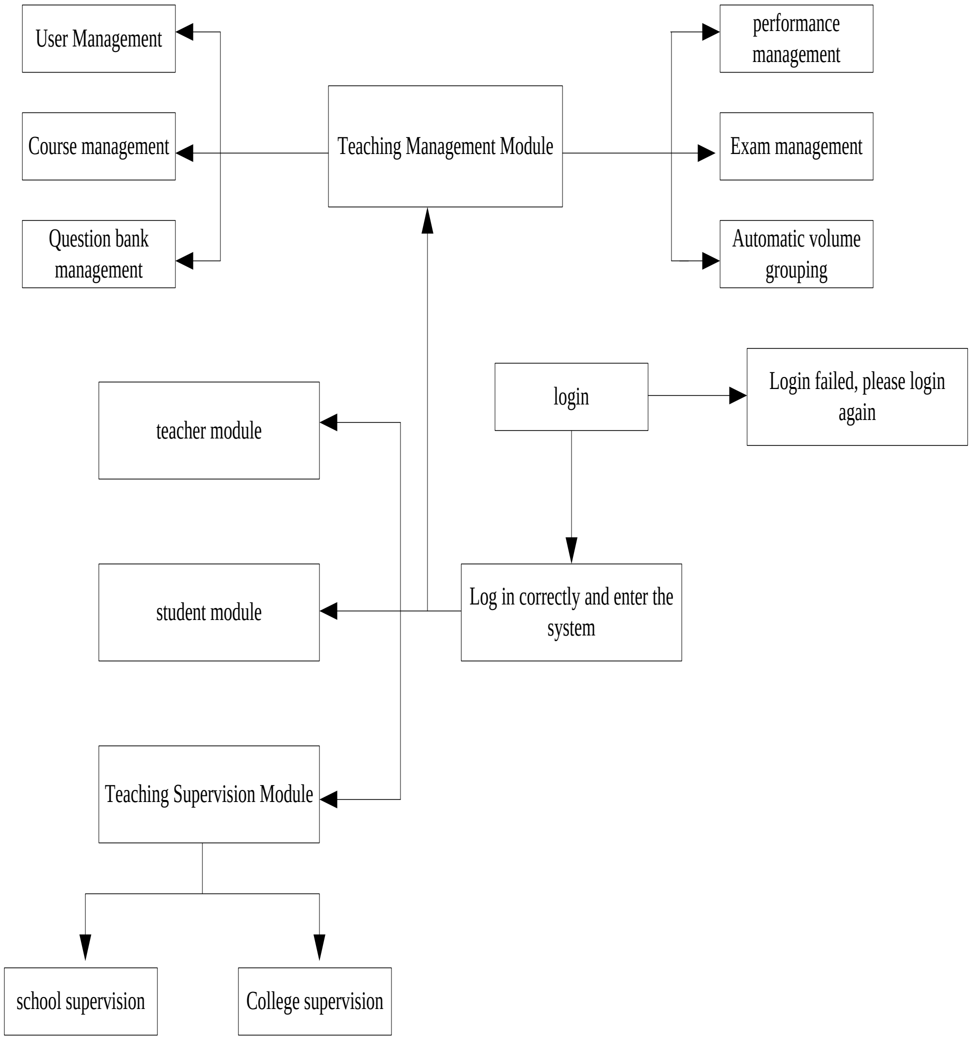

Figure 8. System flow diagram

The login module is implemented to judge whether the user is logged in correctly, and if it is correct, the current user identity is recorded, so that the corresponding role can be operated after entering the system [23]. Entering the system: select the login identity, fill in the correct user name and password, and then enter the system, and according to the different login identity, there will be operations with corresponding permissions after entering the system. If the user name or password entered is incorrect, a prompt will appear, only when all fields are filled correctly will they enter the system.

The administrator module mainly implements the management setting function [24]. Only when the identity is an administrator, the teacher evaluation indicators and weight percentages can be set. Its function is shown in Figure 9.

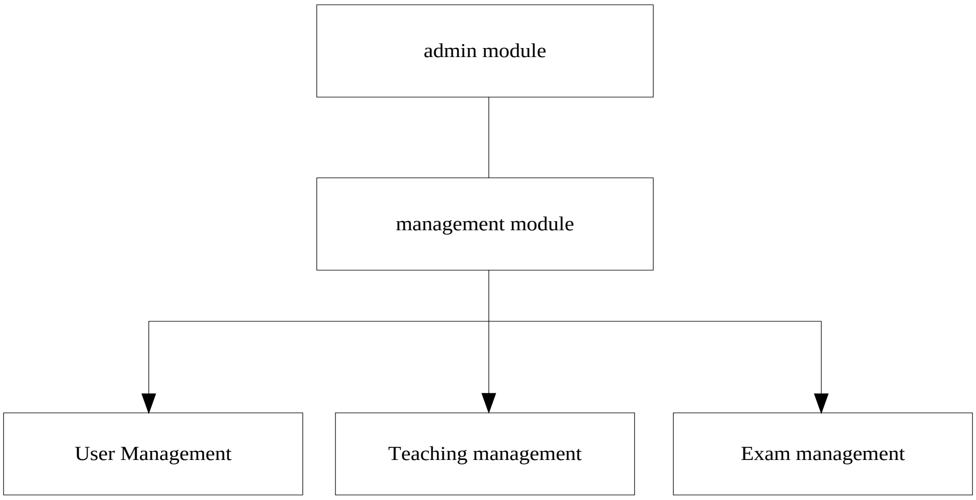

Figure 9. Administrator function module

User management: after logging in with administrator rights, add, delete, and modify existing users according to the school's personnel status and enrollment [25]. Teaching management: after logging in with administrator privileges, divide courses and schedule courses according to school and college teaching plans. Exam management: after logging in with administrator rights, the student modules such as exam arrangement according to the school and college teaching plan mainly realize the evaluation of teachers by students, and can view their own evaluation functions. Only students can evaluate the teachers who teach them, and can see which teachers have completed the evaluation and which have not been completed. Its function is shown in Figure 10.

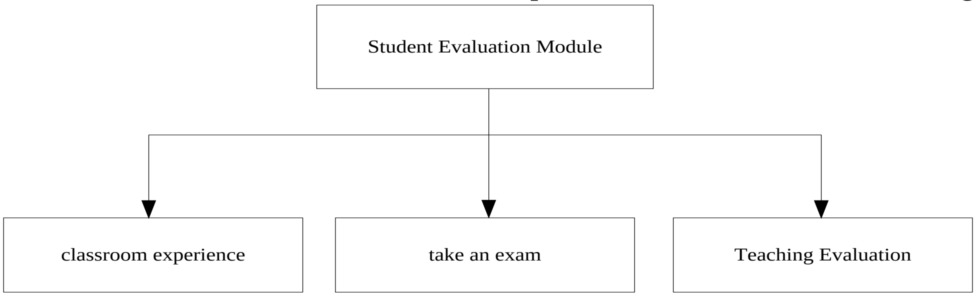

Figure 10. Student evaluation function module diagram

The teacher module mainly realizes the teacher's evaluation of the teacher, and can check the function of self-evaluation. Only teacher can evaluate other teachers, and can check which teachers that have completed and which have not. Its function is shown in Figure 11.

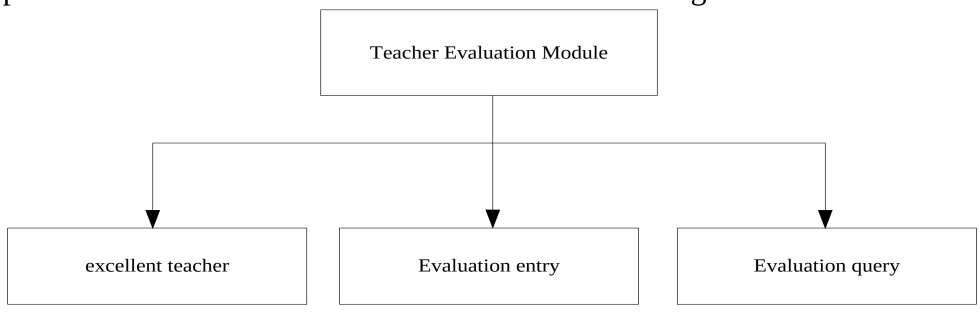

Figure 11. Teacher evaluation function module diagram

(1) Excellent teachers: after logging into the system correctly, click on the excellent teachers to see the photos of the top 20 teachers rated as excellent. This is not only convenient for students to refer to when choosing courses, but also can motivate teachers to work harder to improve themselves.

(2) Evaluation portal: when the login identity is a teacher, click on the evaluation portal to enter the teacher evaluation interface, and score other teachers realistically according to the content of the evaluation indicators. After all evaluations are completed, submit it.

(3) Evaluation query: when the login identity is a teacher, it can click the evaluation query to see which teachers have completed the evaluation and which teachers have not yet evaluated.

4.2. Database Design

Based on modern storage, the teaching management information database integrates, optimizes, cleans and analyzes the data in the teaching process. The entire teaching management information system involves three major technical fields, and the corresponding points are shown in Table 2:

Table 2. System domains

Computer field	Hardware	Software	Algorithm	Programming
Communication field	Internet equipment	Network protocol	Network structure	Software
Information field	Collect message	Information extraction	Information analysis	Information presentation

The teaching management information system is not only an information management system for students and teachers, nor is it a simple evaluation system for students' teaching effect. The teaching management information system mainly includes the student system, the teacher system, the teaching and research room system, the teaching supervision system and the educational affairs management system. The specific functions are shown in Table 3:

Table 3. System functional composition

Student system	Teacher system	Teaching supervision system	Teaching management system
1.classroom experience	1.lesson plan management	1.school supervision classroom experience	1.user management
			2.course management
2.classwork	2.classroom teaching	2.school supervision work inspection	3.question bank management
	3.classroom teaching		4.performance management
3.test scores	4.exam test	3.school supervision classroom experience	5.exam management
4.teaching evaluation	5.self-evaluation	4.school supervision work inspection	6.automatic volume grouping

The main functions of this system are reflected in the addition, deletion, modification, search and statistical operations of various information, including basic user management (addition, deletion, modification and search of users). Each part of the information does not exist independently, but is connected with each other. The specific requirements are shown in Table 4.

Table 4. Functional requirements table

Function number	Function name	Function description	Constraint
1	Login	Teacher login	The login name and password are correct to enter
		Teaching supervisor login	
		Student login	
		Admin login	
2	Manage settings	User login	Restricted to users with administrator privileges and teacher privileges
		Course management	
		Question bank management	
		Exam management	
		Performance management	
		Automatic volume grouping	
3	Student evaluation	Classroom experience	Student users only
		Take an exam	
		Teaching evaluation	
4	Teaching	Lesson plan upload	Teacher users only
		Teaching plan	
		Scientific research results	
		Exam test	
		Teachers' mutual evaluation	
5	Supervisory evaluation	College supervision classroom listening	Restricted to supervised users
		School supervision classroom listening	

4.3. Realization of Teaching Function Module

In terms of power consumption of terminal nodes, only the use of batteries can meet the needs of long-term power supply, and one-to-multipoint and two-point peer-to-peer communication can be realized. It features advanced power management, auto-recovery, auto-configuration and more to coordinate any sensor and facilitate data communication.The visual monitoring software platform has the function of displaying sensor status and node status. Node wireless signal strength RSSI value and node sensor state change curve can control the entire Zig Bee wireless sensor network.

A data-centric network, that is, a wireless sensor network. The network needs to collect a large amount of basic data, aggregate the basic data, and manage the sensor network through further judgment and calculation. The sensor node has several steps such as collecting data, receiving and executing manager commands, completing related management tasks, coordinator node and router/sensor node software design process, create a software design platform, identify program files to write, generate executable files, download executable files and functional testing. The basic process is shown in Figure 12.

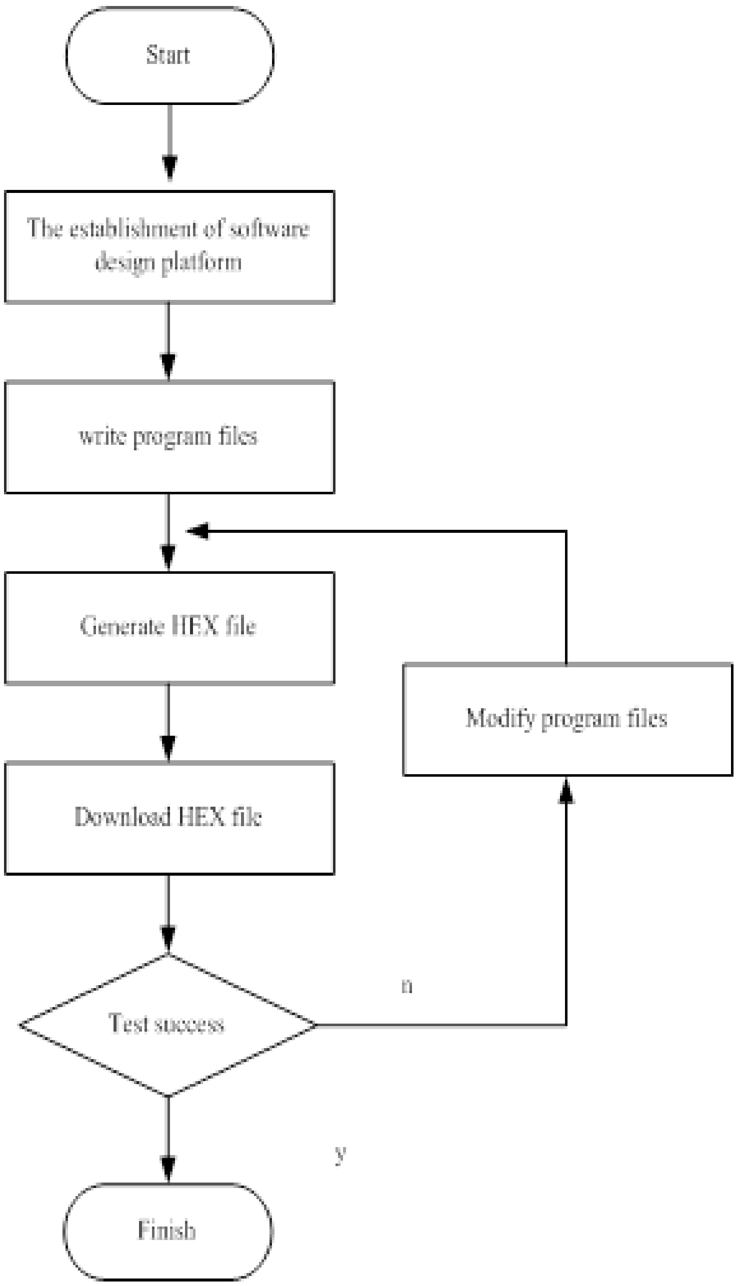

Figure 12. Basic flow chart of ZigBee node software design

4.4. Performance Management Test

Performance management is embodied in statistics and collection of performance management information, such as information related to sending and receiving data, delay, packet loss rate, and so on. At the same time, considering the actual situation of statistics, that is, it takes time, so it is usually necessary to design a certain time interval, preferably 5 minutes. Through design, statistical analysis of all node performance information of network nodes. Figure 13 shows the packet loss rate of a specific node.

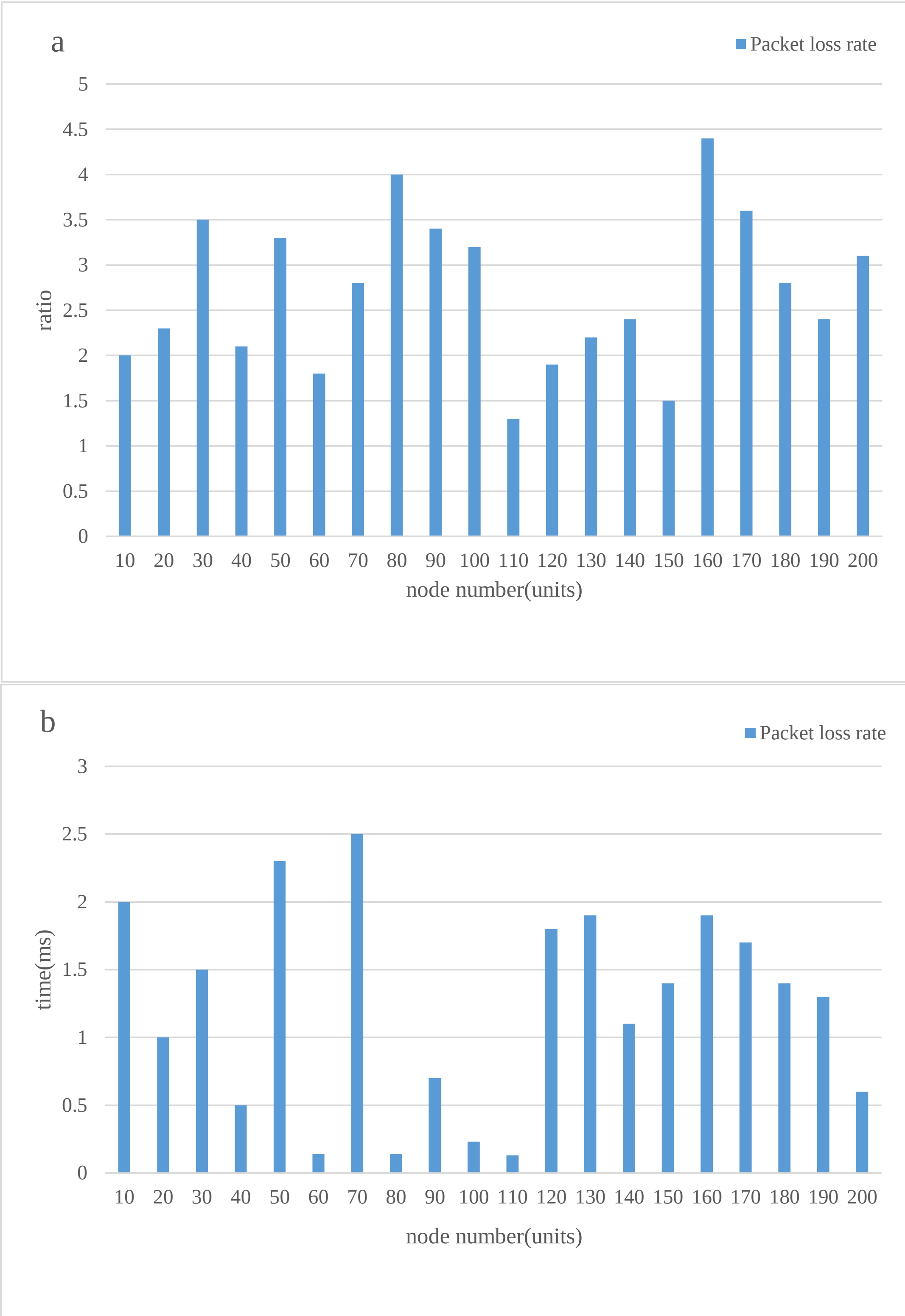

Figure 13. Collected node packet loss rate histogram and average delay

The statistical calculation results show that the average private contract rate of 20 nodes reaches 26.9%, of which the highest and lowest are 44% and 13% respectively. As shown in Figure 13, the average delay of 20 nodes within 5 minutes reaches 0.97 seconds, of which the highest and lowest delays are 1.8 seconds and 0.26 seconds, respectively. In addition, it is found through the graph that the node 20 is closest to the gateway, which fully shows that the node delay is related to the gateway distance.

Based on the above test results, it is shown that the network topology display module will change accordingly with the change of nodes, whether it is joining or leaving a node, it can correctly display the topological structure of the sensor network.

5. Discussion

This paper reforms the traditional teaching method through wireless sensors, and combines theoretical knowledge with practical courses, which is a systematic and coherent teaching method. By designing a teaching management system by integrating teachers, students, theoretical courses, practical courses, simulation experiments, examinations, and student evaluations, it can not only enrich students' knowledge but also improve their practical ability, which is conducive to improving students' innovative ability.

Conduct research on the data link layer and network layer of communication technology for wireless data transmission and reception, systematically explain students' theoretical knowledge through the teaching management system, reinforce theoretical knowledge understanding, track students' practice after class, and interactively exchange practical experience in class. The purpose is to improve students' interest in learning industrial wireless sensor network courses, and break the stereotyped and boring teaching methods of traditional teaching.

6. Conclusion

Through wireless sensor network and database technology, a teaching management system is designed in detail. The system has multiple functions such as collecting, analyzing and storing data, which provides a construction basis for the design of students' science and practical teaching courses. The wireless sensor network system is functionally tested, and the test fully shows that the design fully meets the design requirements. The overall optimized layout of the courses related to sensors and detection technology, and the construction of a theoretical teaching system and an experimental and practical teaching system that integrates the content and structure of sensor series courses. On this basis, a new teaching mode of sensing technology to improve students' professional skills, engineering practice and innovation ability is explored. Interlinking the student system, teacher system, teaching and research room system, teaching supervision system and educational administration system is beneficial to the interaction between teaching, students, teachers and schools.

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Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

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