Resource sharing system of college English education based on wireless sensor network

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Abstract: In order to solve the problems of low efficiency and poor security of college English education resource sharing, a resource sharing system of college English education based on wireless sensor network is proposed. The overall function of the resource sharing system is designed. In the hardware design of the system, the hardware of the wireless sensor node is designed. The model of PIC18LF6680 microprocessor is selected, and the standard RS232 serial port is extended to MAX232 level converter. Digital sensors are designed to realise the high-speed transmission of shared resources. On this basis, the hierarchical structure of the system is designed. In the software part, Kalman filter is used to detect noise and measure noise. According to different network conditions, the delay of wireless network system is controlled. The results show that the maximum sharing efficiency of the system is 98%, and the energy consumption of the system is low.

Keywords: wireless sensor network; WSN; college English; educational resources; sharing system.

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1 Introduction

With the rapid development of China's cross-border economy, foreign exchange business is increasingly frequent. The demand for English majors is increasing in the talent market. The English level of college English majors is closely related to the quality of college English teaching (Yousefpoor and Barati, 2020). The differences in teaching concepts, teaching methods and teaching contents in colleges and universities lead to a certain gap in college graduates' English level. Among them, the sharing of English education resources is one of the important factors that affect college students' English level. Nowadays, the limited and uneven distribution of English teaching resources has become the key to the promotion of quality education and the improvement of the quality of personnel training.

Influenced by many factors such as economic conditions and school scale, the hardware resources of each school are unevenly distributed, which restricts the development of educational informatisation as a whole. Most of the English teaching resources are downloaded or purchased from the internet, and the availability of these downloaded and purchased teaching resources is poor, so it is difficult to integrate them. In the aspects of network popularisation, resource base construction and management, the sharing of educational resources between teachers and schools is less, and the distribution of teaching resources is very unbalanced. Teachers use less teaching resources in actual teaching, the media of resource bank is idle, and excellent teaching resources fail to play their due role (Tao et al., 2019). The development of educational informationisation is restricted by the imbalance of resource construction, the shortage of local resources and the shortage of resource sharing. It is an urgent problem to make full use of all kinds of educational resources and realise educational equity under the current conditions in the development of college English education. Therefore, a lot of researches have been carried out in this field.

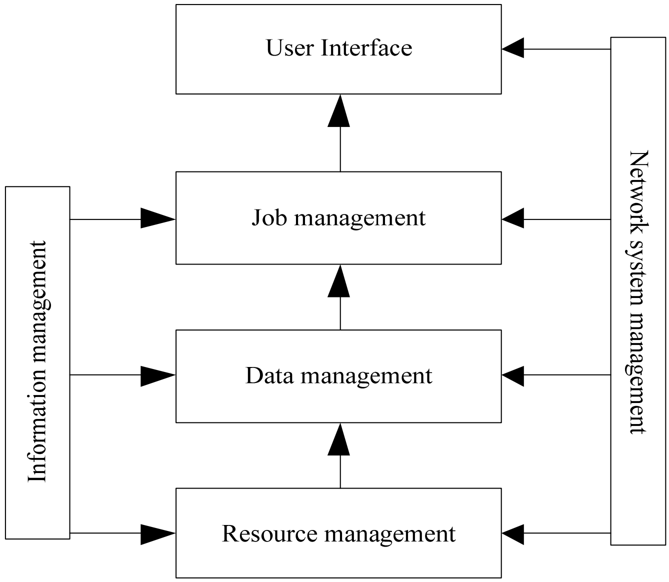
Afif et al. (2019) propose the design of university teaching resource sharing based on SOA architecture. This design uses SOA architecture to integrate the teaching resources of colleges and universities. On the basis of the original sharing system, it refines the resources in the system, thus completing the sharing design of teaching resources of colleges and universities. The design has achieved certain effect in theory and can share online resources, but the effect of sharing is not good in practice. Jiang et al.(2019) proposes the design of the encryption and compression storage system for massive education resources. The system designs the whole structure of educational resources, analyses the interface function of each module, compresses the educational resources in the system by multi-level directory storage method, and sets the key for encryption. The storage speed of educational resources is fast, but the encryption level is low and the security performance is poor. Varghese et al. (2019) propose the design of web service-based education resource sharing platform. On the basis of SOAP, WSDL and the technical characteristics of web, the platform develops the education resource sharing platform by using Axis2, JSP and Tomcat technology. The platform can achieve the functions of creating, publishing, searching and exporting education resources, and the sharing effect is good. However, the design of the platform does not consider the safety performance of education resources, there are certain security risks, the operation is complex and the sharing efficiency is average.

Based on the above problems, this paper proposes to design a resource sharing system of college English education based on wireless sensor network (WSN).

2 Overall function design of resource sharing system of college English education

The resource sharing system of college English education designed in this paper mainly includes six functional units: information management unit, resource management unit, data management unit, user interface display unit, activity management unit and network management unit, as shown in Figure 1.

Figure 1 Function design of resource sharing system of college English education



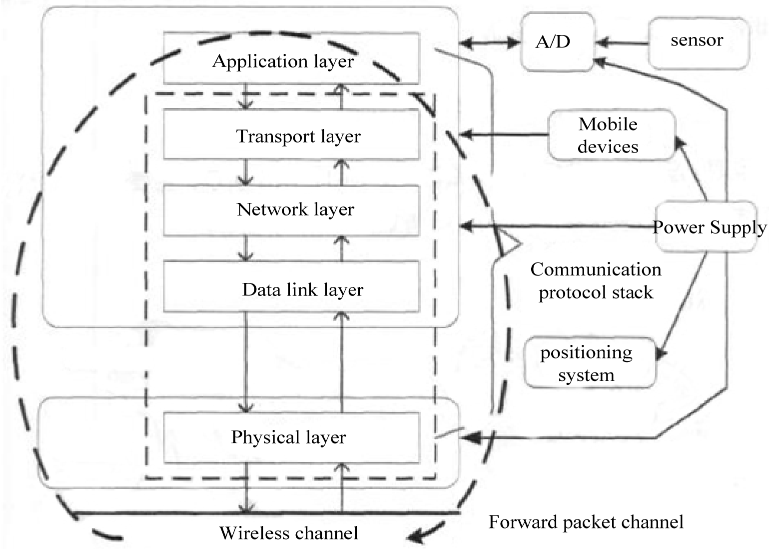
Among them, the network information management unit is responsible for managing the storage, collection, query and update of network education resource information, and supporting users to use college English resources. The resource management unit is responsible for the management of college English teaching resource information, and its main responsibilities are discovery, description, distribution, positioning, migration, preservation, etc. The data management unit mainly includes the transmission, storage, backup and management of English education resource data, which enables users to share the storage resources on the network. Job management unit mainly includes job description, scheduling, management and other functions; the user interface display unit is directly visible to the user, and the user can also carry out certain practical operations through independent requirements. The network system unit supervises and manages the users of the shared resource system. It can charge and set the language, etc., to ensure the stable operation of the network through the network management.

3 Hardware design of English education resource sharing system in colleges and universities

3.1 WSN node

With the continuous progress of network technology, WSN has also made great progress (Asheralieva et al., 2018). It is widely used in hot research fields. WSN combines sensor technology, embedded technology and automatic control technology. Through the integration of sensors, it can achieve a variety of information, environment and other monitoring. The integrated information is transmitted out wirelessly and back to the terminal by self-organising multi-hop mode (Mesquita et al., 2018). Sensor network node is the core of wireless sensor, and its node structure is shown in Figure 2:

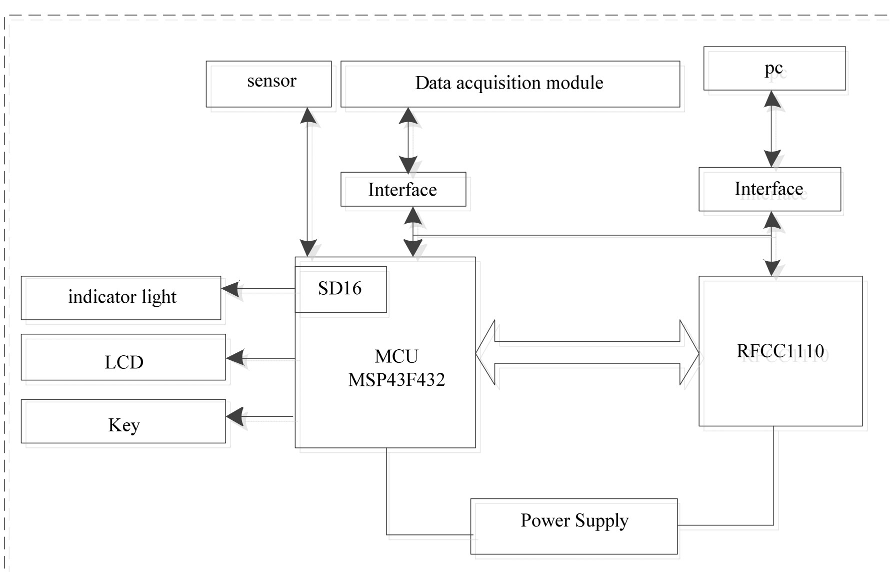
Figure 2 Structure of WSN node



3.2 Hardware design of WSN node

WSN mainly realises its functions through network nodes. In the same sensor network, the function of each network node is different (Xu et al., 2018). In this paper, the wireless network sensor without network node is designed to control the realisation of resource sharing system of college English education design. The specific design is shown in Figure 3.

Figure 3 Hardware design of wireless network sensor without network node



The design of wireless network node includes wireless communication module, MCU, power module and display module. In the design of node circuit, the data acquisition and control of English education resources are used to realise the wireless transmission and management of English education resources in colleges and universities. MSP430F423 (Verma and Sharma, 2019) is selected as the single-chip microcomputer in the node design. It obtains the college English education resource data through the circuit interface, and transmits the collected information through the wireless transmission module. In the design, PC is directly connected with CC1110.

3.3 Super node design of wireless sensor

In the design of resource sharing system of college English education, the wireless sensor nodes include super nodes and terminal nodes. All nodes are connected with each other through WSN. Super node provides terminal node discovery, resource publishing and content location services for the system, and also provides registration information of all terminal nodes and metadata for educational resource sharing system. These two nodes are mainly responsible for local resource management, educational resource sharing, metadata file generation, etc. Based on the IEEE802.15.4 experiment package of Freescale Semiconductor Company (Madhavi and Madheswaran, 2019), the hardware node design of WSN is presented. Considering the requirements of modular design, the super nodes of host unit and RF communication unit are designed. PIC18LF6680 microprocessor is selected as the core processor of super node master control unit, which has 8-bit RISC processor core in internal, and 10 MHz clock drive in external. There is a phase-locked loop inside, with a maximum speed of 40 MHz and a maximum capacity of 10 MIPs. The on-chip memory system includes 64 K enhanced self-programming flash memory, 3.5 K high-speed full static random access memory and 1 K electric erasable programmable memory; in addition, the processor also integrates many external devices, such as: ICD debugger, three timers, one universal asynchronous transceiver, one synchronous serial port, I2C bus, SPI interface, 10 bit analogue-to-digital converter, etc., which are used for programming/debugging in the system (Ghosh et al., 2019).

In the peripheral equipment of the processor, four buttons are expanded to input command information; four groups of digital tubes and two LEDs are expanded to display the working status of the node; in fact, the buttons and displays of the equipment form a simple man-machine interface, which is convenient for the development and debugging of the node software (Gumaida and Luo, 2019). In order to facilitate the debugging of the interface, the standard RS232 serial port is used to expand the MAX232 level converter. The user can observe the working condition of the node through the computer; by fully considering some instruments, the CAN bus is used. The CAN bus interface has been expanded from SN65HVD230 transceiver to the protocol supporting the CAN bus interface (Nguyen et al., 2019). In object-oriented protocol, considering the needs of connecting different hardware devices, the node expands a set of mixed interfaces composed of digital, analogue, interrupt input, etc., so that the node can connect with the hardware; in addition, the node also retains the RF signal interface connected with the RF communication unit, through which the host unit can supply power for the RF communication unit and realise the RF communication unit configuration and RF transmission and reception of data signals at the same time. The host can be externally connected with 3.6 V–12 V DC power supply or vehicle battery, and LED is used to indicate whether the power supply exists; the external power supply or battery power supply can realise efficient DC conversion through AMS1117-3.3, so as to obtain the 3.3 V power supply required by microprocessor and RF communication unit (Upton et al., 2018).

3.4 Design of digital sensor

In order to ensure the sharing effect of the system, a digital sensor is designed in the system, which transmits the sharing information of college English education resources by signal. The system data bus, address bus and control bus are combined to make the whole system work in the order specified in the single line bus protocol. In order to make the bus suitable for other devices, a three state gate is used as the single line bus protocol to ensure that the empty data line of each device will not leak data when connected to other devices. The bus needs an external pull resistance.

Under the support of single line bus protocol, in order to distinguish different devices on the bus, 64 bit binary ROM code is written as chip serial number, so that each device can be identified by addressing. DS1820 type sensor is used, 3-pin PR-35 or 8-pin SOIC is used, GND is used for grounding; I/O is used as data input/output terminal, PR-35 is used as drain output; the digital sensor includes parasitic power supply, 64 bit laser dynamic memory single line interface and note type static memory, which is mainly used to store shared resources. Only one port line (single line interface) can read or write DS1820 information from DS1820, and obtain college English education resources from data bus. Because the bus itself also provides power for the additional DS1820, through the 9-bit resource readings provided by the DS1820, a multi-point resource acquisition system without external hardware is constituted. When DS1820 is used, most of the data acquisition is realised by single chip microcomputer. The DS1820 signal line is connected with the unit port line of single chip microcomputer, which can realise multi-point resource acquisition.

3.5 Hierarchical structure design of resource sharing system of college English education

Based on the above hardware design of wireless network sensor node, the hierarchical structure of resource sharing system of college English education is designed. Resource sharing system of college English education follows the principle of ‘internal protection and external protection’, that is, all universities and other educational institutions, education resource sharing system can use the system of resource access, must be authorised by the system, otherwise external users enter the system without permission, which will pose a certain threat to the system security. This principle not only ensures the system to give full play to the function of resource sharing, but also ensures the security of system operation (Hao et al., 2018; Dong et al., 2018).

The hierarchical organisation structure mode is adopted. The three-layer structure is divided into WSN, regional network and campus network from top to bottom. It is not only convenient for management, but also can ensure the efficient operation of the system. On this basis, engineering group, research group and project group in WSN are established, and the system functions are designed (Kumar et al., 2018). The hierarchical structure of resource sharing system of college English education is shown in Figure 4.

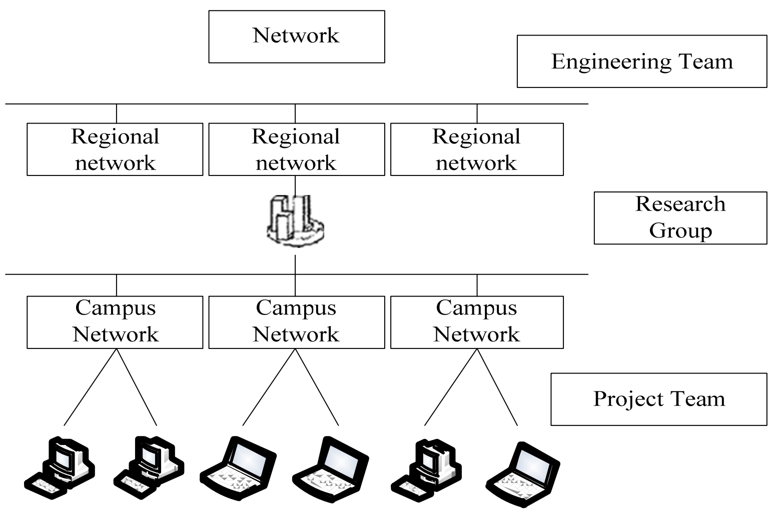
1 Engineering group in WSN is responsible for the construction and maintenance of the whole system, which is the core of the whole education resource sharing system. The regional network is connected with the education resource network of each city and county, and the English groups of each city and county are organised, coordinated and managed.

2 According to the characteristics of college English teaching resources, the designed engineering team of system distributes this task at different levels, and finally collects the characteristic resources provided by different levels, so that college English teaching resources can be shared.

3 The research group is established on the basis of the original county's and city's teaching and research offices, mainly responsible for the collection, design, development, maintenance and management of regional network of teaching resources. It is the main node in the resource sharing system of college English education. The campus network of the school is connected with the regional network, and the team is composed of experienced excellent teachers and technicians.

4 Through the school's local area network, the college English teaching resources are maintained and shared.

Figure 4 Hierarchical structure design of resource sharing system of college English education



This paper designs the hardware of resource sharing system of college English education, including wireless communication module, MCU, power module and display module. In the node hardware design, the super node of the host unit and RF communication unit is designed in detail, and PIC18LF6680 microprocessor is selected as the core processor of the super node master control unit, which has strong processing capacity, the maximum speed reaches 40 MHz, and the maximum capacity reaches 10 MIPS is also expanded to ensure that the designed system node hardware can support the normal and high-speed operation of resource sharing system of college English education.

4 Design of system software

4.1 Kalman filter

After the above hardware design, in order to avoid the interference of noise and signal in WSN, it is necessary to filter it. In WSN, due to the existence of process noise and measurement noise, the resources sharing efficiency of college English teaching is low. In order to achieve more accurate resources sharing of college English education, according to the measurement value of the sensor, a filter under unknown or different interference conditions is designed to remove the noise interference in the signal. Filter algorithm (Wu et al., 2018) can detect process noise and measurement noise. The state space model and the measurement model of the linear discrete system are as follows:

$$\begin{aligned} Q_k &= \alpha_{k,k-1} Q_{k-1} + E_{k-1} u_{k-1} + \beta_{k-1} w_{k-1} \\ Z_k &= C_k Q_k + v_k \end{aligned} \tag{1}$$

In formula (1), α represents the resources system sharing matrix of college English; E represents the transfer matrix; represents the sharing process noise; W_{k-1} represents the observation noise; Z_k represents the measurement value containing the measurement noise; Q_k represents the spatial state value of the linear discrete system. For the relationship between the shared process noise and the observed noise of the system, the following statistical characteristics can be used to describe it mathematically:

$$\begin{aligned} &X\left[w_{k-1}\right] = X'_W(k, j) = 0 \\ &X\left[v_k\right] = X'_v(k, j) = 0 \\ &X'_{Wv}(k, j) = 0 \end{aligned} \tag{2}$$

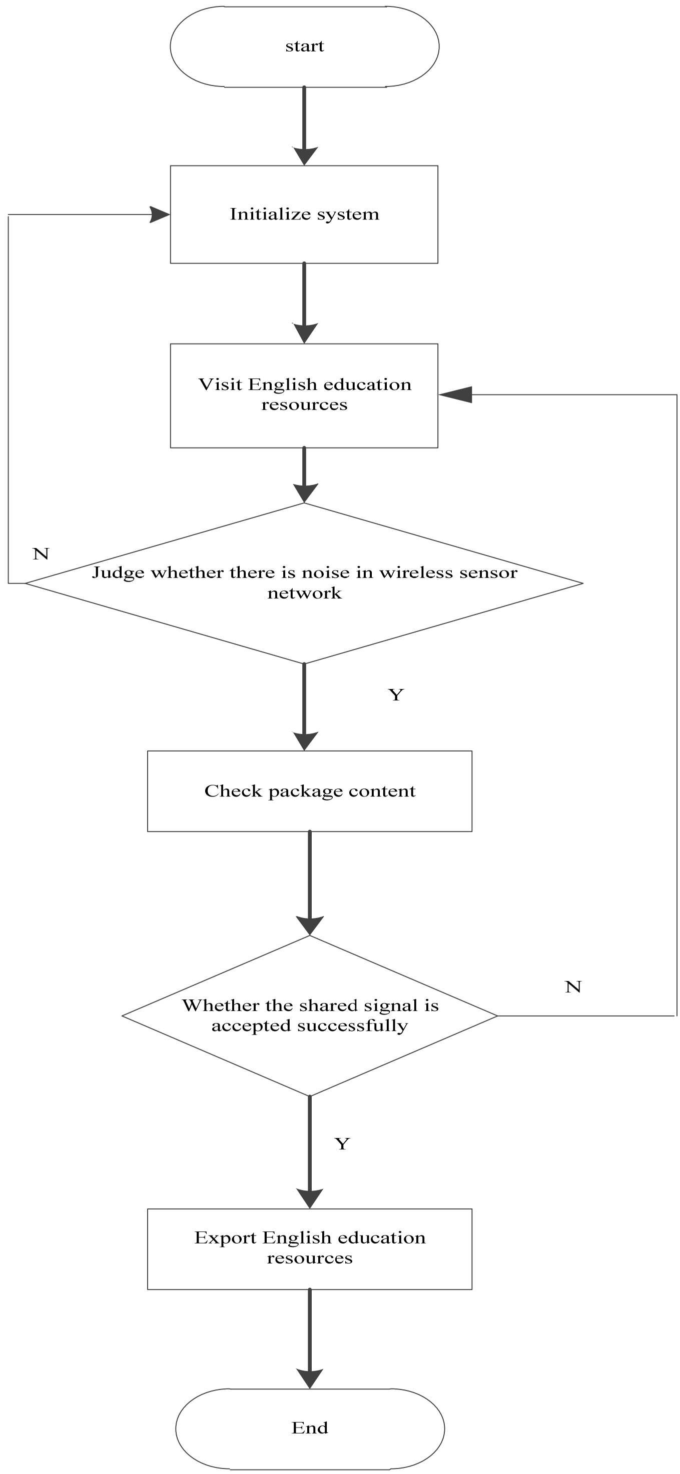
In formula (2), $X'_W(k, j), X'_v(k, j)$ represents the covariance of shared process noise and observation noise at two time points k, j, and X'_{Wv} represents zero, indicating that there is no correlation between shared process noise and observation noise, that is, they are independent of each other. Because the shared system has both shared process noise and observation noise (Fu et al., 2019), there are some errors in the measurement results of the system. According to the measured value and the statistical characteristics of noise, the system is estimated by filtering.

At time $k + 1$, the estimated state value at time k will be called, and the mean square error will be called at time k to correct the filter mean square error. In the design process of Kalman filter, the objective sharing function should be determined first.

$$f = X'\left[\mathrm{e}_k, e_k^T\right] \tag{3}$$

In formula (3), $e_k \overset{\Delta}{=} a_k - \hat{a}_k$ indicates the error between the initial state vector a_k of the system and the changed vector $\hat{a}_k$. Because the Kalman filter is a kind of state prediction filter, the initial value of state estimation and the mean square deviation of filter should be considered. For any given initial filtering error, the Kalman filter will converge, and the mean square error will converge to a fixed value at exponential speed. The final recursive filtering does not depend on the size of the error.

Figure 5 Software implementation process



4.2 Delay control of wireless network control system

In the designed resource sharing system of college English education, due to the different environment of the users, there may be a certain network delay in the sharing of English education resources, which needs to be dealt with. In the structure of WSN, according to different network conditions, the source node is regarded as the data sender and the target node as the data receiver (Nancy et al., 2020).

According to the state value estimated at the time is called, resource sampling is carried out, including the network delay of the sensor information measurement packet arriving at the digital sensor, namely:

$$T(k) = T_D + rT_S + T_f(j) + T_e + T_W \tag{4}$$

In formula (4), T_D represents the time spent by the transmitting node in detecting the state of the resource sharing channel, T_S represents the time slice, r represents a random number from 0 to the minimum conflict avoidance time, $T_f(j)$ represents the time spent by the source node in transmitting the data packet at time, j; T_e represents the encoding time spent by the sampling information uploading at the source node, T_W represents the time that a measurement packet waits to be sent in the send buffer queue.

In the whole system control process, except for the different information content, the measurement data package has no difference. Therefore, in the k^{th} sampling time, the delay of the system control packet arriving at the actuator is the same as that of the network containing the sensor information measuring packet arriving at the digital sensor. Therefore, in the whole process from the generation of measurement signal to control command, for a complete closed-loop, the whole network delay control is as follows:

$$T'(k) = 2T_{SIFS} + 2T_{ACK} + T(k) \tag{5}$$

In formula (5), T_{SIFS} represents the delay after the controller node and the actuator node successfully receive the packet; T_{ACK} represents the time spent by different nodes in the network after successfully receiving the packet. The overall process of system software implementation is shown in Figure 5.

5 Experimental analysis

5.1 Experimental environment

MATLAB software is used to simulate the current control experimental device of the BLDCM, and the effectiveness of the designed resource sharing system of college English education based on WSN is verified by the simulation experiment. The purpose of the simulation experiment is to fully consider the network delay between the sensor and the controller and simplify the analysis process by controlling the motor phase current under the WSN conditions, as shown in Figure 6.

Figure 6 Experimental device

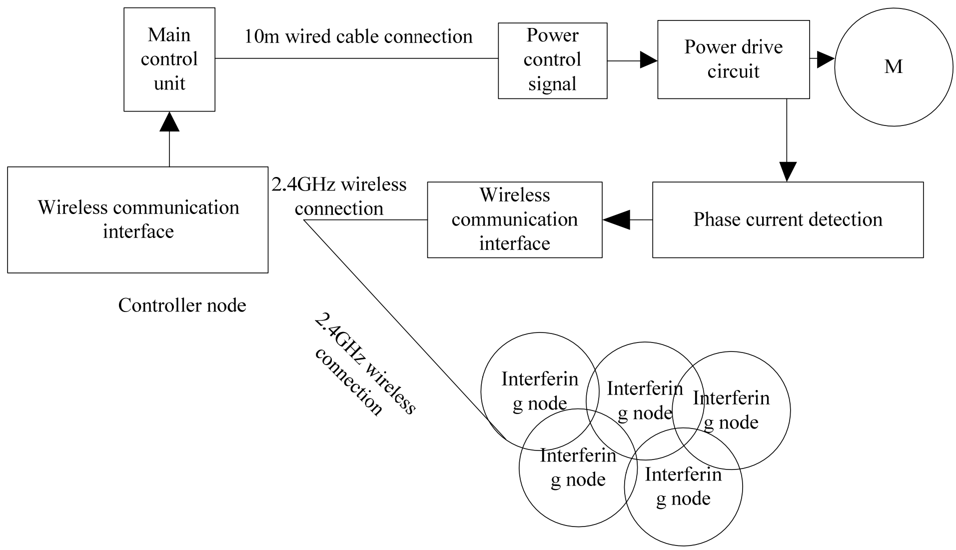
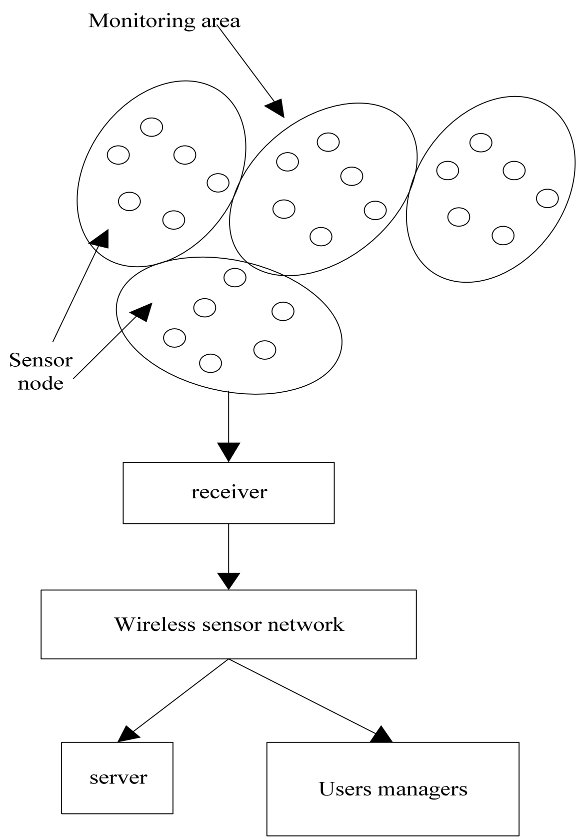


Figure 7 Network topology



As shown in Figure 6, the experimental device is mainly composed of three parts: the first is the motor power drive circuit, the circuit module is directly connected to the network node, which can be used as the sensor node for simulation experiment through the expansion port; the second is the node on the main controller, which can be used as the control node of the controller in the experiment; the third is other network nodes. By sharing the wireless channel with the sensor nodes, these nodes form a small WSN, and send information irrelevant to the control task to the controller nodes, thus forming interference nodes. Before the experiment, MATLAB is used to simulate the software and get a set of simulation data. According to these methods, the simulation data is compiled and programmed into the program memory of the network node by software, and the corresponding experimental results are obtained.

Java is as the development language, struts is as the system framework. In the development of the system, tomcat is used as the application server and SQL Server 2012 as the database management system. In addition, Myeclipse 7.0 is used as a development tool. The Cooja network simulator is used to simulate the experiment, and HMACMDS algorithm is used to generate message authentication code, which is combined with tinyDTLS library to authenticate the data source. Figure 7 shows the network topology used in the simulation.

Information delay is not considered in the simulation process. The previous trust value is the same as the newly generated trust value in the current trust value, so all the weights are set to 0.5. In the simulation experiment, it can analyse the decline of the total trust value of the normal node caused by the misinformation.

5.2 Experimental parameters

The experimental parameter design is shown in Table 1.

Table 1 Experimental parameters

Parameter	*Value*
CPU/GHz	3.6
System running memory / GB	8
English education resource size / GB	4
Access time / s	60
Iterations / time	10

5.3 Experimental index design

In order to verify the comprehensive effectiveness of the proposed method, the experiment compares the sharing efficiency, sharing time and system energy consumption of the system in this paper, the system in Jiang et al. (2019) and the system in Varghese et al. (2019).

1. Sharing efficiency: this index is an important experimental index to measure the system. The higher the sharing efficiency is, the better the system effect is.
2. Sharing time: this index refers to the time used to access resources under the same experimental conditions. The shorter the access time is, the shorter the sharing time is.

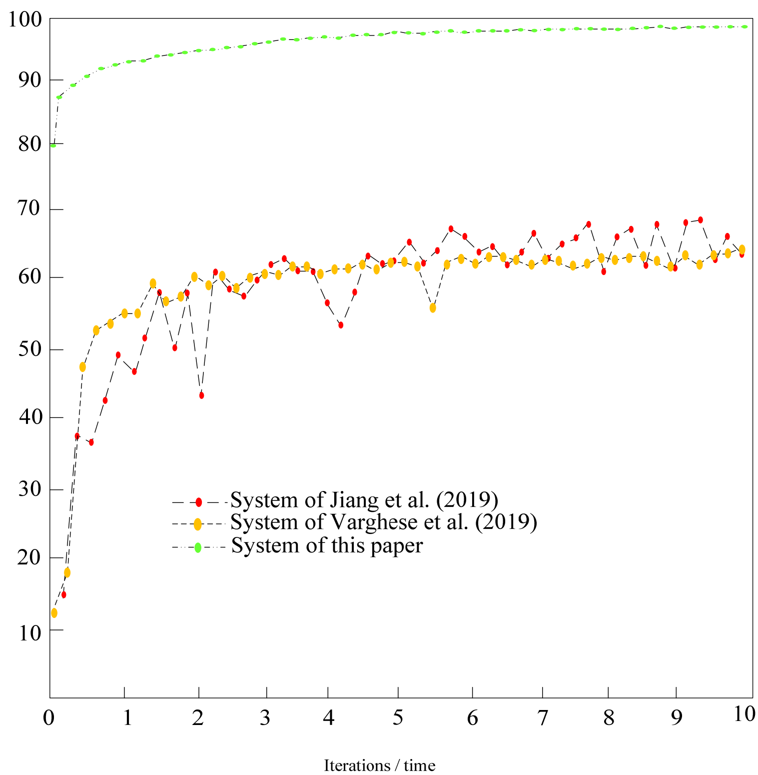
3 System energy consumption: the designed system should not only realise its functions, but also consider its energy consumption to reduce the energy consumption of system design.

5.4 Analysis of experimental results

5.4.1 Analysis of resource sharing efficiency of different systems

In the sharing of English teaching resources in colleges and universities, there are some interference factors that may lead to the low efficiency of system resource sharing. The experiment analyses the resource sharing efficiency of the system in this paper, the system in Jiang et al. (2019) and the system in Varghese et al. (2019). The experimental results are as follows.

Figure 8 Comparison of resource sharing efficiency of different systems (see online version for colours)



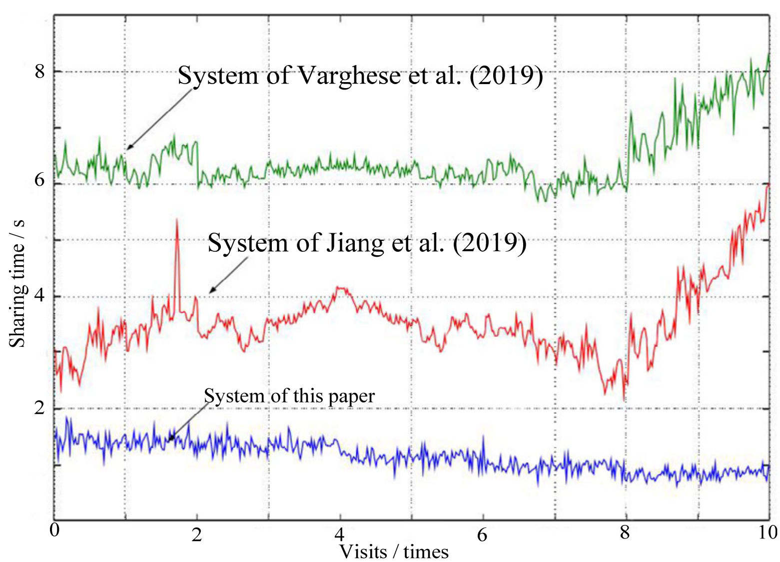
From the analysis of Figure 8, it can be seen that there is a certain gap in the efficiency of using three systems to share college English education resources. From the curve trend in the figure, it can be seen that the sharing efficiency of the system in this paper continues to rise, while the sharing efficiency of the other two systems fluctuates to some extent, and the overall trend is lower than that of the system in this paper. Among them, the sharing efficiency of the system in this paper is up to 98%, that of the system in Jiang et al. (2019) is up to 63%, and that of the system in Varghese et al. (2019) is up to 61%. In comparison, the sharing efficiency of the system in this paper is better, which verifies the efficiency of the designed system.

5.4.2 *Time consuming analysis of resource sharing in different systems*

When we visit the resource sharing system of college English education, the access time of the shared resource is the key index to reflect the response speed of the system. The experiment compares the time-consuming of the system in this paper, the system in Jiang et al. (2019) and the system in Varghese et al. (2019) when accessing shared resources, and the experimental results are as follows:

Analysis of Figure 9 shows that in the same experimental environment, the resource access time for the three systems is different. Among them, the time-consuming of the resources sharing system in this paper is less than 2 s, while the other two systems are always higher than the system in this paper, and show an upward trend. In comparison, the time-consuming of the resources sharing system in this paper is shorter, which verifies that the response speed of the system in this paper is faster.

Figure 9 Comparison of resource sharing time of different systems (see online version for colours)



5.4.3 *Energy consumption analysis of different systems*

System energy consumption is an important index to measure the quality of system design. Experiment is carried out to analyse the system in this paper, the system in Jiang et al. (2019) and the system in Varghese et al. (2019) system in the operation of the energy consumption. The experimental results are shown in Table 2.

It can be seen from the data in Table 2 that with the increase of system operation times, there is a certain gap in energy consumption among the three systems. When the operation times are 6, the energy consumption required for the system operation in this paper is 15 W, the energy consumption required for the system operation in Jiang et al. (2019) is 28 W, and the energy consumption required for the system operation in Varghese et al.

(2019) is 36 W; when the operation times are 10, the energy consumption required for the system operation in this paper is 16 W, the energy consumption required for the system operation in Jiang et al. (2019) is 34 W, and the energy consumption required for the system operation in Varghese et al. (2019) is 38 W; comparing the three systems, it can be seen that the energy consumption required for the system operation in this paper is the minimum. This is because the proposed system filters the noise of system access, saves the number of data processing and reduces the energy consumption of system operation.

Table 2 Comparison of operation energy consumption of different systems (W)

Times of operation	*System of this paper*	*Jiang et al. (2019) system*	*Varghese et al. (2019) system*
2	15	23	35
4	16	26	32
6	15	28	36
8	17	32	38
10	16	34	38

6 Conclusions

When the traditional resource sharing system of college English education is accessed, its access effect is not good, and the efficiency of English education resource sharing is not high. To solve this problem, this paper proposes the design of resource sharing system of college English education based on WSN. The hardware of wireless sensor node is designed, and the processor of super node is selected. Through the design of signal sensor, the collection of shared information of college English education resources is realised. In the software part, the noise in the operation of wireless sensor is processed, and the time delay is controlled to complete the design of English education resources sharing system. Compared with the traditional sharing system, the proposed system has the following advantages:

1 The sharing efficiency of the system can reach 98% at most, which has some advantages.

2 When we visit the English education resource sharing system, the visiting time is always less than 2 s.

3 The lowest energy consumption of the system is about 15 W, which is lower than that of the traditional system.

Although this paper has made some achievements in the system design at this stage, there are still many deficiencies. In the future, it will be improved in the following aspects:

1 In the system design, the cost is not considered too much in the hardware selection.

2 In the design of wireless sensor nodes, the hardware only supports the existing functions, not the extended functions.

3 In the system delay control, only the network delay when the sensor information measurement data packet arrives at the digital sensor is considered, and other factors are not considered too much.

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