Energy-saving Renovation of Air Conditioning in Technical Schools Based on the Internet of Things

Xiaonao Lin\textsuperscript{1} and Changyao Yang\textsuperscript{2,\ast}

\textsuperscript{1}School of Mechanical and Power Engineering, Guangdong Ocean University, Zhanjiang 524088, China
\textsuperscript{2}Zhanjiang Preschool Education College, Zhanjiang 524084, China
\textsuperscript{\ast}Corresponding author e-mail: 87963685@zpec.edu.cn

Abstract. In public places such as teaching buildings and dormitories, a single air conditioner does not seem to consume much energy, but the entire school consumes a lot of energy. Designing a series of air-conditioning energy-saving systems that can be automatically controlled to protect students' body temperature while achieving energy saving and reducing energy consumption is an important research direction at present. The research purpose of this article is based on the analysis and research of energy-saving renovation of air conditioning in the Internet of Things technical school. The main purpose of this paper is to further realize the remote monitoring of campus air conditioning system in our country. Taking our campus air conditioning system as the main research object, we will develop a new campus air-conditioning monitoring system composed of air-conditioning monitoring terminal, monitoring terminal and air-conditioning control center. The monitoring department uses wireless communication technology to solve the energy consumption problem of traditional campus air conditioners. At the same time, it also establishes a network of remote sensors and remote monitoring, so that the monitoring and control methods of remote sensors during the operation of air conditioners are not affected by any region. According to experimental data, the Internet of Things technology effectively reduces the energy consumption of air conditioners by 30\%, and indirectly reduces manpower consumption.

Keywords: Internet of Things Technology, Automatic Control, Remote Monitoring, Cloud Computing

1. Introduction

1.1. Background and Significance
In recent years, while promoting the sustained and high-speed growth of my country’s economy, it is also accompanied by the huge pressure brought by the global energy shortage and environmental degradation. As a main body of energy saving, air-conditioning enterprises themselves should actively adopt advanced energy-saving management methods and scientific methods. Technology to manage
the comprehensive utilization of energy [1]. The new generation of advanced Internet of Things technology combined with the basic research related to the new generation of energy management information technology can achieve the effect of energy saving and environmental protection under the premise of ensuring a reasonable temperature, and the maintenance and operation are more convenient and faster [2-3]. Therefore, each school puts forward higher requirements for air-conditioning control, hoping to realize the air-conditioning remote management system and intelligence.

1.2. Related Work
Learn ideas from the Internet of Things and study a variety of energy data collection technologies that use smart sensors as an important part of data collection [4]. The topology of the designed radio sensor network is determined by the star and tree topology grid [5]. The routing protocol of the wireless sensor network protocol adopts the adaptive component layer routing protocol, and is finally based on the wireless intelligent sensor network [6]. Thappatranon P believes that wireless smart sensor networks provide various energy data collection systems and provide implementation models for specific systems. The design process is to add information fusion from multiple sensors to reduce repeated data transmission and reduce energy consumption [7]. Nishii N believes that traditional scheduling schemes often have various problems when applied to practical problems, because traditional scheduling schemes often ignore the complex constraints in practice, often leading to weak scheduling performance [8]. The requirements for intelligent air-conditioning control systems mainly include the ability to adjust the on/off time of the air-conditioning at any time, with diversified control methods, and the ability to perform emergency dispatch, to find faults in time and notify the maintenance personnel to repair them immediately, etc.[9-10]. Traditional air-conditioning systems are often difficult to ensure that the power is reduced, especially when the control box or the wiring is out of order, it may cause temperature discomfort and inconvenience to teachers and students [11-12]. However, due to the rapid development of intelligent control, their research is not very accurate and incomplete.

1.3. Main Content
The innovation of this paper is to use the Internet of Things technology to process data through temperature detection and personnel detection, so as to achieve the on/off control and temperature control of the air conditioning system. The system will be used as a key component of smart sensor data collection to study the structure of a wireless sensor network designed for multi-energy data collection technology. Finally, based on the intelligent wireless sensor network, this system shows the specific implementation format and control method for various energy data collection.

2. Energy-Saving Renovation Methods for Air Conditioning in Internet of Things Technical Schools

2.1. General Principles Law
Before conducting on-site testing, you must first have a certain knowledge and understanding of the system layout. In addition, the specific test content and plan should be determined according to the actual situation and test requirements of the project. There are many test equipment and test methods used to measure each parameter simultaneously. Determine them according to the specific needs of on-site testing conditions, and try to choose a test method with accurate results and easy operation. The tester must be easy to carry. In order to obtain more accurate test data and use the test equipment safely, the test methods and taboos must be paid attention to.

2.2. Air Conditioning System Evaluation Method
We will organize evaluation indicators and explain the characteristics and scope of each indicator. As a result of the comparison, it is finally decided to evaluate the system by selecting the energy
efficiency ratio EER of the air conditioning system, which is an evaluation index suitable for the system. This indicator applies to building air conditioning systems. The calculation is simple and accurate, so you can intuitively understand how the system works, and you can also use the energy efficiency ratio limit of the air conditioning system to determine the energy saving potential of the air conditioning system. The air-conditioning system energy efficiency ratio EER evaluates the operation of the air-conditioning system, that is, the total cooling capacity of the air-conditioning system and the energy consumption of the air-conditioning system. The specific calculation method is as follows:

$$EER_s = \frac{Q}{\sum N_i}$$  \hspace{1cm} (1)

Where Q is the total cooling capacity of the air conditioning system, kW·h.

For the water system transportation coefficient, when used for the evaluation of the overall cumulative working conditions, the minimum limit of WTFCHW is 30. When the end of the system is a single type, the specific indicators of the air conditioning end energy efficiency ratio limit are shown in Table 1.

| Air conditioning end type                                      | Air conditioning terminal energy efficiency ratio limit |
|---------------------------------------------------------------|------------------------------------------------------|
|                                                              | Annual accumulative working conditions | Typical working condition |
| All air system                                                | 6                                     | 8                          |
| Fresh air + fan coil system                                  | 9                                     | 12                         |
| Fan coil system                                               | 24                                    | 32                         |

Judging from the existing energy consumption indicators in the data, selecting and evaluating the energy efficiency ratio EER of the air conditioning system suitable for the system is of great help to the energy saving of air conditioning. Calculate the EER of the system obtained through the Internet of Things control, and the comparison shows that the system has at least 30% energy saving space.

3. Based on the Experiment of Energy-Saving Renovation of Air-Conditioning in Technical School

3.1. System Construction Experiment

According to the type of ZigBee node, street lamp terminals can be divided into two types: one is a terminal acting as a router node, and the other is a simple air-conditioning terminal device. The two types of nodes are mainly distinguished by the ZigBee module. The air conditioner mainly collects street lamp status data through any independent circuit module and its sensors, and transmits it to the monitoring terminal coordinator node through the air conditioner’s ZigBee module. The structure of the system, the hardware circuit is divided into two parts, the hardware circuit of the air conditioner terminal and the monitoring terminal. According to the system structure, the hardware circuit is divided into two parts for introduction, the air conditioner terminal hardware circuit and the monitoring terminal hardware circuit. The hardware circuit modules introduced in this chapter are the underlying equipment, and the direct control object is each air conditioner in the campus air conditioning system. It is called an air conditioning terminal in this system. Using a simple power intensity detection circuit composed of temperature-sensitive resistors, sliding rheostats, and operational amplifiers, the temperature-sensitive resistors are placed next to the light source. Adjust the resistance of the sliding rheostat and set a fixed threshold. When the light intensity is greater than the set threshold, \( V > V \), the output terminal outputs low level.

$$V_\text{out} = \frac{R_1}{R_1 + R_0} \times 220V$$  \hspace{1cm} (2)
R1 is the air conditioner resistance and R0 is the temperature-sensitive resistor. According to formula 2, when the air conditioner fails or the power is insufficient, the resistance value of the temperature-sensitive resistor Rn increases and V decreases until $V < V_+$, that is, the voltage at the positive input terminal is greater than negative. For the voltage at the input end, the output end of the operational amplifier outputs a high level to the single-chip microcomputer. When the single-chip microcomputer judges whether the street lamp has a fault by judging whether the pin receives a high level.

3.2. Smart Sensor Network Construction Experiment

Smart sensor is a kind of system designed and manufactured by imitating the senses of humans and organisms and expanding its functions. It consists of sensors and microprocessors. Among them, the microprocessor is the core part of the smart sensor, which can calculate, store and process the data collected by the sensor, and then adjust the sensor through the feedback loop. Due to the limited number of sensor nodes, the network topology must be designed according to the characteristics of the application scenario, so that the sensor network can adapt to the application environment, so as to avoid unnecessary losses, improve the efficiency of the sensor, and extend the effective service life of the entire network, improve the stability and reliability of the network. Currently, there are generally three types of sensor network structures: star structure, tree structure and mesh structure. The structure of the sensor network is shown in Table 2:

|                      | Advantages                                      | Disadvantages                                      |
|----------------------|-------------------------------------------------|----------------------------------------------------|
| Star structure       | Networking is the easiest to implement          | Communication distance is limited and coverage is small |
|                      |                                                 | As the number of network stages increases, the probability of transmission delays and packet loss increases |
| Tree structure       | Accommodates more child nodes                   | Higher requirements for hardware                   |
| Reticular structure  | The network mode is flexible and the coverage is large |                                                    |

It can be seen from the above that with the rapid development of modern automation systems, the accuracy and intelligence level of sensors puts forward high requirements for remote maintenance, accuracy, stability, reliability and compatibility, but traditional sensor technology can no longer meet. We need to develop a new type of smart sensor, the smart sensor used in this system has a relatively large advantage compared with ordinary sensors.

4. Experimental Data Analysis

Due to the increasing scale of the industrial production process and the increasingly complex and changeable production environment, massive and multi-source data are generated in the production process. However, the existing manufacturing system lacks effective means of obtaining real-time data, which often leads to data collection. In this system, the ZigBee module acts as a communication bridge between the air-conditioning terminal and the monitoring terminal. It occupies a vital position in the wireless network of the entire street lamp system. The wireless network composed of ZigBee includes all air-conditioning terminals in the network. Realize the monitoring function of all air conditioners. The physical layer is responsible for sending data out and receiving data from the antenna. In the campus intelligent street lamp system, the street lamp terminal sends the state information of the street lamp through the physical layer of the ZigBee protocol, or receives control commands sent by the Zigbee physical layer of the coordinator module.

4.1. Analysis of the Operating Conditions of the Cooling System

The cooling system is an integral part of the air conditioning system, which is the channel for heat exchange between the system and the outside world. The cooling system used in the building studied
in this system is an open water surface, cooling tower. The cooling tower not only accounts for any part of the total energy consumption of the air system, but also affects the efficiency of the cooling operation. Therefore, the problem of cooling towers cannot be ignored. The air volume and water volume of three cooling towers were tested, and the test results are shown in Figure 1:

![Figure 1. Test data of cooling tower operating conditions](image)

Since we can see that the amount of cooling water corresponding to each cooling is 300 m³/h, it is necessary to adopt the operation mode of one machine and one tower. However, there is a problem in that when two units are operated in parallel under actual operating conditions, three cooling towers are lighted, and when one cooler is operated, the amount of illumination of the two cooling towers is reduced. At the same time, the measurement data shows that the air volume and air volume distribution of the cooling tower are uneven, which is one of the reasons for the low efficiency of the cooling tower. The heat exchange effect of the cooling tower affects the ratio of cooling energy efficiency. In addition, as a result of investigating the on-site situation, it was found that mold and dust had accumulated on the intake filter plate at the bottom of the cooling tower.

4.2. Analysis of Operating Conditions of Air Conditioning System
Regardless of the fan coil unit, the air-conditioning system in the building adjacent to the main building is mainly composed of outside air. Outdoor air units are installed on each floor of the main building and auxiliary buildings, with approximately 600 fan coil units. The education building on the 6th floor of the annex is equipped with air conditioning and a complete air system, which can withstand the heat and humidity in the room. In order to analyze the performance of the fan coil unit, we tested some common indoor fan coil units. The test result is shown in Figure 2.
Figure 2. Test data of some fan-coil operating conditions

It can be seen from the above table that the performance of the fan coil unit is significantly reduced, and the airflow and cooling capacity exceed the nominal value. The performance of some fan coil units is significantly reduced, and fan coil units are produced, which not only cannot meet the cooling requirements of the room, requirements, reducing the indoor thermal comfort, and wasting the cooling capacity of the system. Testing the performance of the fan coil unit also found other problems, such as poor ventilation, blockages and uneven airflow, and large operating noise. Utilizing the designed wireless sensor network structure and network protocol, designing a collection system for multiple energy data, designing the system's framework and network architecture, and finally giving the energy monitoring and energy-saving management system the realization of multiple energy data. The specific implementation form of the acquisition system.

5. Conclusions

At present, the air-conditioning system of most public buildings has many problems due to unreasonable design or operating conditions, such as excessive selection of chillers and water pumps, equipment efficiency not reaching the rated value, system operation and maintenance management in time and so on. All of these make the energy consumption of the air-conditioning system remain high, so the energy-saving transformation of the air-conditioning system of this part of the building is imminent, and its energy-saving potential is also very huge. It has a strong practicality for the energy-saving transformation of the air-conditioning system based on the Internet of Things technology school. Bring a new direction to future energy conservation.

References

[1] Hui T K L, Sherratt R S, Sanchez D D. Major requirements for building Smart Homes in Smart Cities based on Internet of Things technologies. Future Generation Computer Systems, 2016, 76(nov.):358-369.

[2] Balaji M S, Roy S K. Value co-creation with Internet of things technology in the retail industry.
Journal of Marketing Management, 2017, 33(1-2):7-31.

[3] Wang S, Yin H, Zhang W, et al. Applied Research of Internet of Things Technology in Agricultural Greenhouse. Journal of Physics: Conference Series, 2020, 1575(1):012223 (5pp).

[4] Zhao S, Li S, Yao Y. Blockchain Enabled Industrial Internet of Things Technology. IEEE Transactions on Computational Social Systems, 2019, 88(99):1-12.

[5] Kopp R, Bensberg R, Stollenwerk A, et al. Automatic Control of Veno-Venous Extracorporeal Lung Assist. Artificial Organs, 2016, 40(10):992-998.

[6] Yang S M, Lin K W. Automatic Control Loop Tuning for Permanent-Magnet AC Servo Motor Drives. IEEE Transactions on Industrial Electronics, 2016, 63(3):1-1.

[7] Thanpattranon P, Ahamed T, Takigawa T. Navigation of autonomous tractor for orchards and plantations using a laser range finder: Automatic control of trailer position with tractor. Biosystems Engineering, 2016, 147:90-103.

[8] Nishii N. Remote monitoring of cardiac implantable electronic devices. Trends in Cardiovascular Medicine, 2016, 26(6):568-577.

[9] Bashi N, Karunanithi M, Fatehi F, et al. Remote Monitoring of Patients With Heart Failure: An Overview of Systematic Reviews. Journal of Medical Internet Research, 2017, 19(1):e18.

[10] Elisa Spanò, Pascoli S D, Iannaccone G. Low-Power Wearable ECG Monitoring System for Multiple-Patient Remote Monitoring. IEEE sensors journal, 2016, 16(13):5452-5462.

[11] Chen X, Jiao L, Li W, et al. Efficient Multi-User Computation Offloading for Mobile-Edge Cloud Computing. IEEE/ACM Transactions on Networking, 2016, 24(5):2795-2808.

[12] Chandra S R, Yafeng W. Cloud Things Construction - The integration of Internet of things and cloud computing. Future Generation Computer Systems, 2016, 56(C):684-700.