Design of Central Air-conditioning Partition Scheduling System Based on WLAN Positioning

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Abstract. A partition scheduling system of central air-conditioning based on Wireless Local Area Network (WLAN) positioning is designed. The system can quickly update the personnel density of the partition by WLAN positioning algorithm, and obtain the actual load by integrating the temperature and humidity and the surrounding partition information. Therefore, the rotating speeds of the fans and water pumps of the air conditioning in this area are automatically adjusted, so as to realize the intelligent scheduling of the air conditioning in different areas based on personnel density. At the same time of regional differentiation, the overall cooperative operation can truly achieve the energy-saving effect of distribution on demand.

1. Introduction
China's energy consumption of central air-conditioning accounts for 50% of public buildings, which is the largest exceeding the total energy consumption of lighting, elevators and office equipment. Energy conservation of central air-conditioning has become the key to reach the standard of energy conservation in public buildings. When selecting air conditioning, the capacity is often large, and the control strategy is unreasonable, which eventually leads to serious energy waste in actual operation of the system. For the central air-conditioning system, water chillers and fans account for more than half of the energy consumption and become the main equipment for energy conservation research.

The development trend of central air-conditioning system is systematization, intelligence and energy conservation. However, the traditional system widely used in the market at present has caused great economic losses while wasting resources. Therefore, the energy conservation control system of central air-conditioning has great market prospects.

With the rapid development of Internet of Things technology in recent years, the layout range of local area network (LAN) is wider and the positioning cost is lower. Therefore, the value of LAN is fully exploited and applied to the central air-conditioning energy conservation system without additional system overhead, which meets the requirements of energy conservation and environmental protection in the long-term vigorous development of ecological civilization construction.

2. System Introduction
A partition scheduling system of central air-conditioning based on WLAN positioning is designed. The public area covered by the central air-conditioning is divided into several areas according to the spatial structure and the physical distribution characteristics of the air conditioning terminal devices. Temperature measuring devices and humidity measuring devices are installed inside a single area as the most basic information source for central air-conditioning control.
The system ensures that each intelligent terminal entering the area can receive more than three AP signals. When the new intelligent terminal is connected to the LAN, the background server can receive the equipment signal strength information RSS in real time, match the fingerprint database, realize fast positioning, and update the personnel density information in the corresponding area. On the basis of information such as temperature and humidity, the server calculates the air conditioning load change caused by the change of the number of people in the area, and superimposes it to calculate the total load. At the same time, each adjacent area affects each other spatially, and its synergistic effect also serves as an important source of information. Therefore, the central controller obtains the air output volume required by the air conditioning and the corresponding water volume change integrating temperature, humidity, personnel density, surrounding area information, etc.

After completing the signal processing and calculation, the central processing unit controls the rotating speeds of the fans and water pumps of each area air conditioning to achieve the effect of energy conservation. At the same time, all the data of the system are displayed in real time on the LCD screen of the upper computer, which has a good human-computer interaction interface and can also interact with the mobile phone end of the administrator to realize remote centralized monitoring.

3. Partition Population Measurement based on Indoor Positioning Algorithm
The application of indoor positioning algorithm in the intelligent control field of central air-conditioning changes the traditional camera acquisition mode, which avoids the problems of object shielding and high system installation cost. It makes full use of LAN resources, and achieves low cost at the same time with high efficiency.

In order to quickly and accurately count the number of people in indoor partitions, and control the air output of each air inlet of the central air-conditioning and the operating power of the water pump, as well as meet the requirements of simplifying the equipment and cost of the measurement system, this project selected the indoor positioning algorithm based on WiFi to measure the number of people in each
partition. At present, WLAN is widely deployed indoors, and wireless network cards are configured on various mobile devices. Therefore, it is possible to obtain the received signal strength RSS of each mobile device. An indoor signal propagation model is constructed. Based on the existing k-Nearest Neighbor (KNN), an improved WKNN and weighted triangular localization algorithm are adopted to solve the problems of large data noise, high data volume requirement and low matching efficiency in traditional localization.

Figure 2. Flow Chart of Indoor Positioning

3.1. Establishment of indoor space signal propagation model
In free space, there are:

\[ P \propto \frac{1}{d^2} \]  

(1)

Where P is the power of the signal \( d \) represents the distance, and they are inversely proportional to the square.

The signal strength of the point with distance \( d \) in the corresponding space is:

\[ \text{RSS}(d) = \text{RSS}(d_0) - 10n \log\left(\frac{d}{d_0}\right) \]  

(2)

The above formula is from \( n=2 \), and a common Log-distance Path Loss Model is established. However, it is still quite different from the real indoor environment. Because the actual signal will be blocked and reflected by obstacles in the propagation environment, the indoor spatial signal propagation model can be constructed by using ray tracing technology on the basis of the Log-distance Path Loss Model of the signal and combining various reflected, diffracted and scattered signals generated by the signal encountering the wall in indoor transmission.

3.2. Online fast positioning algorithm
Aiming at the problems of low matching efficiency and high computational complexity caused by large amount of fingerprint database data in real-time fingerprint database matching and positioning, we adopt an improved online fast positioning algorithm. WKNN method is obtained by weighting calculation on the original KNN, which reduces the number of reference points required for positioning, i.e. the K value, and correspondingly reduces the dimension size of operation data. At the same time, the fingerprint database is preprocessed before positioning, and the filtering parameter \( \rho \) of the current area is obtained through the method of area fusion, so as to measure the correlation degree between the data
to be located and a certain area, reduce the number of matches in the positioning fingerprint database, and improve the matching speed. Figure 3 shows on-line rapid positioning in an 18*18m model.

![Figure 3. Simulation Diagram of Online Rapid Positioning Environment](image)

4. Variable Wind and Variable Water Quantity Partition Control of Air Conditioning Based on Personnel Density Change

The central processing unit (CPU) calculates the change of air conditioning load caused by the fluctuation of personnel density in the corresponding area, superimposes it with the information of temperature, humidity and surrounding areas, and cooperates with each other at the same time of differentiation to obtain the air output volume required by the air conditioning in each area and the water quantity change matched with it. Compared with the existing global control strategy of central air-conditioning, the local control strategy of partition is adopted, which takes the change of human flow as the main fluctuation factor, and integrates the temperature and humidity as well as the information of surrounding areas to obtain the actual air conditioning load, taking into account the coordination of the whole system while differentiating between areas. It fully embodies the superiority of the partition control model.

4.1. Calculation of cooling load under different person flow

The cooling load power formed by human body heat dissipation at time $t$ is

$$Q_i(t) = N(q_1k_i + q_2)\phi_1\phi_2$$

Among them, $N$ is the number of people in the area, and $q_1$, $q_2$ is the sensible heat and latent heat (W/person) of each adult man per unit time respectively. $k_i$ is the apparent heat dissipation cooling load coefficient of the human body and $\phi_1$ is the cluster coefficient. The denser the correction personnel of the actual heat dissipation caused by mutual absorption and exotherm between human bodies, the smaller $\phi_1$. $\phi_2$ is the membership factor [1]. The difference in cooling load of human body heat dissipation in different areas and different times is the main reason for the difference in air conditioning control strategies in different areas and different periods. After calculating the cooling load of human body heat dissipation, it is superimposed with the relatively stable cooling load formed by other factors to obtain the total cooling load as the basis for variable air volume and variable water volume control.

4.2. Variable wind and variable water control model of air conditioning based on human flow

The coverage area of the central air-conditioning is divided into several areas according to the spatial
structure and the physical distribution characteristics of the air conditioning terminal devices. The personnel density information is substituted into the mathematical model to calculate the cooling load change, which is superimposed with the information of temperature, humidity and surrounding areas to calculate the actual cooling load of the area. At the same time of coordination between areas, each area realizes differentiated control, formulates control strategies according to human system, fully exploits energy conservation potential, and flexibly controls the frequency of fans and water pumps to achieve overall energy conservation optimization.

For buildings such as libraries and large shopping malls, the temperature change depends on the flow of people, the heat generated by lighting and electrical equipment, the heat radiation around building walls, and the heat brought by ventilation. Among these factors, passenger flow is the most important factor for temperature fluctuation, and other factors are generally in a relatively stable state, so its influence is ignored and personnel density is taken as the main research object [2], i.e. the basis for regional differentiation control.

In the various energy consumption of the air conditioning system, the energy consumption of the cold air unit and the fan accounts for a large proportion. Considering the cold air unit and the fan comprehensively, the optimal control strategy of variable air volume and variable water volume is proposed. PID control algorithm is adopted, aiming at the lowest energy consumption of the system. It has better energy conservation effect through modeling simulation and solid model simulation [3].

4.3. Construction and implementation of air conditioning variable wind and water volume system

The space is divided into several areas according to the space structure and the physical distribution characteristics of the air conditioning terminal devices. After completing the signal processing and calculation, the CPU controls the rotating speeds of the fans and water pumps of the air conditionings in each area. At the same time, all the data of the system are displayed on the LCD screen of the upper computer in real time and interact with the mobile phone end of the administrator to realize remote centralized monitoring, which greatly facilitates the real-time management of the central air-conditioning system.

Taking a large public library as an example, the public area on the first floor of the library controlled by the central air-conditioning is divided into different areas according to the physical distribution of the terminal devices of the central air-conditioning. A group of DDC controllers control the terminal devices corresponding to the two air conditioning air outlets, and a temperature measuring device is installed near the terminal devices of each air outlet. In order to realize indoor positioning according to WiFi signal strength, intelligent terminals are required to receive more than 3 AP signals at any positioning. As long as the mobile device of the reader entering the library accesses the WiFi wireless LAN of the library, its mobile terminal will send signal strength information to the background server, and the background server can obtain the reader’s positioning and add it to the human flow information in the public area where it is located.

The background server can obtain the matching pre-power consumption value of the corresponding comfortable temperature of the human body under the human flow rate in different areas and the electrical switch degree of the terminal device in different areas under the different population density after establishing the model and trial operation analysis. According to this, a database is established. In actual operation, only the crowd density range in the sub-area needs to be judged. Compared with the parameters in the database, the background server can directly output relevant control instructions to control the terminal device to adjust the regional temperature.

5. Conclusion

1) This project can effectively reduce the energy consumption of central air-conditioning in public buildings. The change of personnel density directly affects the air conditioning load. The project uses wireless LAN positioning technology to realize real-time update of personnel density, to ensure that the central air-conditioning detects the change of cooling load in public places in real time, and to control the air conditioning variable wind and water energy conservation subsystem to automatically adjust the...
rotation speed of fans and water pumps, thus achieving the purpose of energy conservation.

2) Intelligent control makes the temperature in public places more comfortable and humanized. There is a tide of people flow in public places, and there are peaks and valleys of people flow with time. Traditional air conditioning control ignores the temperature fluctuation caused by human body heat dissipation and crowd activities, causing discomfort reaction of overheating or supercooling to human body. This project uses personnel density information to control the terminal device to adjust the temperature in real time to ensure stable and balanced temperature throughout the day and provide the best user experience.

3) Significant exploration has been carried out in building energy conservation and promoting the development direction of low energy consumption in the building industry. Energy conservation of central air-conditioning is the key to reach the standard of energy conservation in public buildings. The use of traditional central air-conditionings has brought huge energy consumption and waste of funds to the society. The intelligent and energy-efficient zonal scheduling central air-conditionings designed in this project have replaced high energy consumption products and played an exemplary role.

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