Intelligent OPC Building Information Management System Based on IoT

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Abstract. With the rapid development of artificial intelligence, computers and Internet of Things technologies, building intelligence is becoming more and more popular. However, as the various functional subsystems and equipment of intelligent buildings are connected to each other, the traditional management system needs to monitor and modulate more and more programs, which will have a great impact on the interoperability of the subsystems. Therefore, a more complete and powerful management system is needed. OPC provides a unified standard that can effectively solve this problem. Therefore, the purpose of this article is to design an intelligent OPC building information management system based on the Internet of Things. This article first summarizes the development history and status quo of OPC technology, and then extends the design principles of building information management system based on OPC. Based on its design principles, a detailed analysis of the various subsystems of the building information management system, such as fire protection, intrusion prevention, monitoring, access control, and central air conditioning, is carried out. This article systematically explained the application of PID in the building information management system. And use comparative analysis method, observation method and other research forms to conduct experimental research on the intelligent OPC building information management system based on computer Internet of things. The research shows that compared with the traditional building management system, the intelligent OPC-based building management system researched in this paper can transmit information faster and have higher accuracy.

Key words: OPC, Intelligent Building, Information Management System, Intelligent Management, Design Research

1. Introduction

Intelligent buildings combine technologies such as computers, the Internet of Things, and artificial intelligence as a whole, and are the informatization products of today's scientific and technological society. Intelligent building technology integrates various technologies such as automatic control and communication, and integrates and manages the equipment in the building to form an interconnected and coordinated system. Provide people with a safer and more comfortable environment and working atmosphere [1-2].
Since the OPC standard is mainly formulated by many well-known foreign automation equipment manufacturers, the application research of OPC technology abroad is more mature [3-4]. In our country, although some manufacturers have developed various application software that meet the OPC technical standards, there is still a significant gap in performance and other aspects compared with foreign countries. However, with the popularization and use of OPC technology, the integration of building automation systems based on OPC technology will become a hot topic in international research [5-6].

The purpose of this paper is to improve the efficiency of building management, and for the purpose of comparative research on the OPC intelligent building management system. By comparing the information management system studied in this paper with the traditional building management system, the feasibility analysis of the theme of this paper is carried out.

2. Design and Research of Intelligent OPC Building Information Management System Based on Computer Internet of Things

2.1. Principles of Overall System Design

(1) Centralized monitoring
On the integrated platform based on OPC technology, the operation status of any equipment or data collection point of any subsystem is monitored in real time, and the information of the underlying equipment is sent to the monitoring interface to display in graphics, text, and voice [7-8].

(2) Centralized control
Operators directly send control commands through the integrated management platform, and can control the operating status and related parameters of any equipment of any subsystem at any time, without having to manually control each subsystem host [9-10].

(3) Real-time alarm
When a certain device or data point of the system is abnormal, or fails, it will send out an alarm in real time by means of buzzer or infrared display [11-12].

(4) Linkage control
The various subsystems of the building initially work independently of each other, and the communication between the systems is realized through the integration of intelligent buildings, so that the entire large system works together, and the signals or actions between the subsystems can be linked through the integrated system. For example, the alarm of the anti-theft alarm system can trigger the closed-circuit television monitoring system to switch the alarm screen to the main monitor, and the public and emergency broadcasting systems broadcast anti-theft alarm notices.

(5) Authority management
The integrated monitoring platform adopts the login method of user name and password, and sets different operation permissions for different login personnel, so as to prevent the leakage of system information and the artificial interference and destruction by illegal personnel.

(6) Man-machine interface
The monitoring interface (HMI) adopts a combination of text and graphics, which is easy to operate and clear.

2.2. Management System Design

(1) Fire protection subsystem
The fire control adopts a centralized fire reporting system, which penetrates multiple regional alarm
controllers to form a larger automatic fire alarm system.

(2) Intrusion prevention subsystem
The system installs infrared sensors at the main entrances and exits and on the walls to form an alarm system without leaving blind spots to prevent illegal border crossings. If someone breaks in and blocks infrared rays, an alarm signal will be sent to the security control center immediately. And it can be used to improve reliability and prevent false alarms by using dual-beam or four-beam infrared rays, which can effectively avoid the influence of debris, small animals, weather, etc. on the infrared sensor, and large objects or any illegal. Anyone who crosses the wall will trigger an alarm.

(3) Closed-loop TV monitoring subsystem
This system takes the video matrix as the equipment unit to form a centralized video monitoring system. It includes the functions of collecting and sending information, forming additional information, and remotely controlling the front end. The multiple output and control keyboards of the video matrix can make the system realize multi-user mode. Each user can enjoy all or part of the system's resources according to the setting of system authority, and can also be used to realize system cascade to form multi-level video surveillance system. At the same time, the video matrix is used to realize remote transmission of images and remote remote control of the system through network technology.

(4) Access control subsystem
The system adopts a centralized structure, and some modules can be added or reduced according to the needs of the project to realize the functions required by the building. The various controllers of the mouth control management system have standard input and output communication connections, which can be implemented conveniently and quickly. Cooperate with other subsystems such as automatic fire alarm system, closed-loop television monitoring system, anti-theft alarm system, etc. The entire building is managed by a console host, which is set up in the central control room on the first floor of the building.

(5) Central air-conditioning subsystem
The central air-conditioning monitoring system designed for this project adopts an H-level network structure. The field equipment control layer is divided into N independent areas according to the characteristics of the central air-conditioning work. The OPC server layer is composed of the main control server and sub-servers based on parameters (temperature, humidity, $CO_2$ amount), and the central monitoring layer is composed of the two parts of the control host client and the monitoring screen are integrated.

2.3. Development of Building Intelligent System Integration Based on OPC
Apply OPC to the intelligent system of the entire building to realize the centralized monitoring, control and management of the fire protection subsystem, intrusion prevention subsystem, access control subsystem, monitoring subsystem and air conditioning subsystem, as well as the interconnection between systems. Provides a way to build intelligent system integration through the development of OPC server enhancements.

The data unit in the OPC server is Item, which is the so-called point tag in industrial process control. In OPC applications, these three items are used: the value of the data (Value), the quality mark (Quality), and the time of data collection (Time Stamp) to describe the process data. Each device corresponds to a point (Tag). To this end, create the following data types in Delphi, create an array to save the role calls, and allow the data on the OPC server to be updated in real time.

```pascal
Type
TTag = record
  ID:string;
```
2.4. Application of PID Control Algorithm in Building Automatic Control System

In the building process control, PID is still the most widely used control method. Its control method is simple and fixed, and it can maintain excellent robustness in a wide range of working conditions. Its control law is as formula (1):

\[ u(t) = K_p [e(t) + \frac{1}{T_i} \int_0^t e(t) dt + T_d \frac{de(t)}{dt}] \]  

(1)

The transfer function is shown in formula (2).

\[ D(s) = \frac{U(s)}{E(s)} = K_p \left(1 + \frac{1}{T_i s} + T_d s\right) \]  

(2)

Among them is \( K_p \) Proportional gain, \( T_i \) Integral time constant, \( T_d \) Derivative time constant, \( u(t) \) is the control quantity, and \( e(t) \) is the deviation.

Differentiate formula (2), replace it with a difference equation and make a proper approximation to obtain formula (3):

\[ u(k) = K_p [e(k) + T_i \sum_{i=0}^{k} e(i) + T_d \frac{e(k) - e(k-1)}{T}] \]  

(3)

Equation (3) is called the positional PID control algorithm. Its output value \( u(k) \) directly controls the actuator, and the value of \( u(k) \) corresponds to the value of the actuator one-to-one. It can be seen from the formula that each output \( u(k) \) is related to the past state, \( e(k) \) must be accumulated during calculation, the calculation amount is too large, so we adopt incremental PID algorithm to solve the above problem. After transforming formula (3) into incremental mode \( \Delta u(k) = u(k) - u(k-1) \), there is formula (4), where \( q_0 = K_p(1 + \frac{T}{T_1} + \frac{T}{T_2}) \), \( q_2 = K_p \), \( q_1 = -K_p(1 + \frac{2T_2}{T_1}) \) \( T \) is the sampling time \( T \).

\[ \Delta u(k) = q_0 e(k) + q_1 e(k-1) + q_2 e(k-2) \]  

(4)

It can be seen that each output \( u(k) \) is related to the past state, \( e(k) \) must be accumulated during calculation, the calculation amount is too large, so we adopt incremental PID algorithm to solve the above problem.

2.5. Advantage Analysis of Intelligent OPC Building Information Management System Based on Computer Internet of Things

(1) Enhance the correlation between subsystems

Improve the control and linkage structure of heterogeneous network environments such as building automation system (BAS), integrated security system (SMS), and fire alarm (FAS) in intelligent buildings. Enhance the interoperability and integration of relevant information between the real-time monitoring computer systems of the building.
(2) **Improve the efficiency of information network integration**
All equipment and safety monitoring information in the intelligent building can be entered into various computer platforms and desktop systems, greatly improving the use of monitoring information in the intelligent building and sharing the comprehensive data of the "group environment". In order to realize the remote control monitoring and data collection of the electromechanical equipment and safety alarm management in the intelligent building.

(3) **Reduce economic costs**
After adopting the new system, the hardware developer provides a unified OPC interface program for the product. The application terminal does not need to understand the essence and operation of the hardware. You can directly call the OPC interface to complete the data transmission and control with the device, so avoid repetitive development of the driver program, greatly reducing the development cycle and development costs.

3. **Experimental Research on Intelligent OPC Building Information Management System Based on Computer Internet of Things**

3.1. **Experimental Protocol**
This experiment went deep into an intelligent terminal building. This experiment compares the information query time and accuracy rate of the intelligent OPC building information management system based on the computer Internet of Things and the traditional information management system. The query efficiency Q can be calculated with the following formula:

\[ Q = \frac{n}{T} \]  \hspace{1cm} (5)

The n in the formula represents the amount of target information to be queried, and T represents the amount of time it takes to query the target information. In the case of a certain number of query information n, the shorter the query time T, the higher the efficiency of the proof information query; similarly, when the information query time T is constant, the more the number of query information proves the higher the information query rate. In order to ensure the accuracy and reliability of the experiment comparison, two managers who participated in the experiment with the same length of service and position were selected to inquire about the prescribed information on the traditional Fangxiong and OPC building intelligent systems.

3.2. **Research Methods**

(1) **Comparative analysis method**
This experiment compares and analyzes the OPC building information management system studied in this article with the traditional building information management system and records data. These data provide a reliable reference for the final research results of this article.

(2) **Field research method**
In this experiment, we went into an intelligent terminal building and carried out field investigations on its building management system and collected data. These data not only provided theoretical support for the topic selection of this article, but also provided data support for the final research results of this article.

(3) **Mathematical Statistics**
Use the relevant software to carry on the statistical analysis to the research result of this article.

(4) **Multidisciplinary research method**
Based on intelligent building theory, system integration theory, computer programming theory and
BIM related theories, combined with domestic and foreign literature research and system integration characteristics, the BIM-based intelligent building integrated management system framework is analyzed and studied.

(5) Case analysis method
This research takes a terminal building as a research case, and uses the BIM intelligent integrated management system for case application through the classification of the specific functional requirements of the terminal building. And summarize the application effects and carry out related comparative analysis experiments.

4. Experimental Analysis of Intelligent OPC Building Information Management System Based on Computer Internet of Things

4.1. Information Query Comparison
The amount of T spent to query the same information as a rule proves the level of Q. The less T spends, the higher Q is. Compare the efficiency of the old and new models by selecting the representative information query L. Select 10 representative query information as samples: L1 = location information of the fire hydrant on the second floor of the corridor of terminal B, L2 = attribute information of the transformer box on the fourth floor of the corridor of terminal C, L3=A is the installation time of the corridor glass curtain wall, L4=D is the installation time of the automatic walkway on the third floor of the corridor, L5=the electricity consumption of the corridor of the terminal building B in February, L6=the electricity consumption of the shops on the second floor of the E area of the terminal building in March, L7= Unit rental price of No. 20 shop in the lobby of the terminal building E, L8=manufacturer information on door 6 of the domestic departure hall, L9=maintenance time of the No. 2 air-conditioning machine room on the first floor of the concourse of the terminal building A, L10=section E of the terminal building Baggage system operation monitoring information. The statistical comparison of the query time T of the above 10 samples is shown in Table 1.

|      | Traditional | OPC |
|------|-------------|-----|
| L1   | 510         | 25  |
| L2   | 930         | 34  |
| L3   | 550         | 25  |
| L4   | -           | 35  |
| L5   | 180         | 65  |
| L6   | 330         | 20  |
| L7   | 210         | 15  |
| L8   | 1100        | 60  |
| L9   | -           | 25  |
| L10  | 890         | 30  |
4.2. Comparative Analysis of Information Transmission Efficiency

The efficiency of information transmission determines work efficiency. This experiment measures the efficiency of information transmission by measuring the time $T$ required for the same target task $N$ to be transmitted from the property management department manager to the frontline maintenance staff. In order to make the test results more accurate, the manager of the property management department was the same test subject, and the front-line maintenance and repair workers who performed the task were two employees of similar working age and age. The recorded start and end time is when the manager issues an order to start information transmission, and it is the cut-off time until the maintenance and repair personnel receive the information. Select 5 target tasks $N$: $N_1$=clean the ground hygiene in the customer service area, $N_2$=repair the automatic ticket vending machine in area A, $N_3$=replace the advertising posters on the railings of area A, $N_4$=maintain the air-conditioned machine room No. 3 on the basement floor, $N_5$=Clean the hygiene of the 6 VIP rooms on the second floor. The time it takes to record the information transmission is shown in Table 2.

|    | Traditional | OPC |
|-----|-------------|-----|
| $N_1$ | 20          | 10  |
| $N_2$ | 16          | 5   |
| $N_3$ | 18          | 3   |
| $N_4$ | 15          | 6   |
| $N_5$ | 23          | 12  |
It can be seen from Figure 2 that the OPC intelligent building management system based on the computer Internet of Things takes less time to transmit information in the same target object than the traditional management model, which shows that the intelligent OPC building information management system studied in this paper is beneficial to improve departmental information transmission.

5. Conclusion
The purpose of this paper is to study the intelligent OPC building information management system based on the computer Internet of things. Through the analysis of the existing building information management system problems, the building management system is developed with OPC technology on this basis. This article also through the detailed analysis of the application of PID automatic control algorithm in the building information management system, in order to obtain a high-efficiency, high-function, high-comfort building.

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