Healthy Building Management System Based on Business Intelligent

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Abstract. Huge account of building performance data are generated, collected and preserved in Building Automation Systems (BASs), which have been widely implemented with the development of smart building technology. Based on the key information which under covered in these data, building performance management plan can be created and improved. As a technology complex which concludes data warehouse, online analysis and data mining, business intelligence (BI) can extract, collect, and analyse large amounts of data to support decision-makers in making business decisions. With the assistance of BI based Decision Support System (DSS), desired information from massive building operation data can be found, which upgraded BAS as smart Building Management System. A business intelligence-based health building management system is introduced in this paper which can collect and store various performance data such as indoor environment quality (IEQ), water quality and energy consumption into one database. After processed with a predefined procedure, all preserved data can be processed and displayed with a user-friendly graphic interface. With the assistant of this BI based system, operating managers can make building management decision or revise management plan much more accurately as well as quickly according to real-time online monitoring data.

1. Introduction
With the development of economy and society, as well as the accelerated process of urbanization and industrialization, the demand of living quality and better environment is also increasing. On the other hand, in recent years, as a sign, smog diffuse in every winter, environmental pollution get much more public’s focus. As a key factor of human health, clean air is highlighted more than ever

The large public buildings are always got air pollution problem because of crowded people and closed space. Research shows that if effective measures are taken to improve the indoor environmental quality, the efficiency of the internal staff can be increased by 15% to 20% [1]. However, there are still many problems in the indoor environmental quality of large public office buildings: indoor environment assessment methods are not completed; indoor environmental quality intelligent monitoring technology is not perfect, lack of effective intelligent monitoring methods; lack of publicity system to show the AQI to residents, so that they cannot know whether the AQI has reached a healthy, efficient standard in their work place. Therefore, installing air quality monitoring systems in public buildings has become a necessary trend.

Building Automation Systems (BASs) are the decision support systems that support the energy management processes that consist of monitoring, analyzing, controlling, and optimizing energy usage.
Overall, BASs minimize energy consumption, and maximize productive conditions and energy efficiency [2]. In the process of the BASs, a large amount of monitoring data has been accumulated in various projects, such as indoor environment data, energy consumption data etc.

BAS comprise activities such as (1) consolidating energy related data from different sources, (2) using data access tools to analyze building performance, (3) visualizing energy related data, and (4) generating reports [3, 4]. The lack of a reference information model can be grasped in BASs with confusing user interfaces (that force users to throw away large amounts of data [5, 6]), and that are limited in terms of analysis capabilities (often forcing energy managers to use spreadsheets to analyze energy data) [7].

With the development of information technology, there is an urgent need for an integrated system to solve the contradiction between "excessive" data storage and lack of decision information. Therefore, the business intelligence (BI) has been introduced as an inevitable choice to improve the level of information.

2. Methodology

Data has become the second major factor in importance only to the business of talent. Business intelligence can integrates and analyses the external data from the company's operating market and the internal data from the company's resources, then extracts valuable information. Enterprise users can be assisted with BI to strengthen their management, making decisions promptly and scientific for future development, as well as discover new business opportunities. Corporate leaders and professional analysts are on longer the only users of business intelligence systems, all decision makers such as corporate managers, the functional persons within the company's internal departments, even customers, suppliers, and partners, can be treated as BI users.

Business intelligence technology can analyze various types of data such as structured, semi-structured, or unstructured data, also static historical data, and dynamic data streams. The business intelligence technology system is mainly composed of Data Warehouse (DW), On-line Analytical Processing (OLAP), Data Mining (DM), and Enterprise Information Portal (EIP). Partially composed, it integrates data discovery, management and decision support as a whole unit. It can integrate enterprise data resources on existing IT infrastructure and provide users with innovative applications and services.

Different from pure data analysis software. Business intelligence analysis software is more intelligent, standardized, and process-oriented towards business activities. Its procedure can be summarized as importing data sources, analyzing data indicators, and displaying data results. Finally, the BI analysis results are presented to end user through various forms such as ordinary reports and visual charts. From the perspective of different business users, the more easy-to-use business intelligence software is, the more popular it is. In order to improve the user experience, the user wants the software to be more convenient and the content of various types of data information is more intuitive. Therefore, the successful user experience needs to be realized through the visual interface of business intelligence analysis software.

3. Case Study

One of the most important features of healthy building operation management is the wide-distributed monitoring equipment, various systems, and high degree of coupling of monitoring data. Building management decision makers cannot inspect meters at real time. Due to lack of professional knowledge, it is difficult to understand the coupling relationship between indoor environment and equipment energy consumption. Therefore, implement business intelligence to guide the operation and management of healthy buildings would be a significant attempting.

Using business intelligence, building operation data can be analyzed, energy consumption can be optimized. The relationship between HVAC operation and indoor environment changing can be induct and proofed. According to the proofed relationship, optimized operating plan can be made in order to minimum energy consumption and improve indoor air quality. Therefore, the target of this system is to
provide a path, which decision makers can either obtain information from the home page or use data analysis tools directly to query information from the data warehouse. Urgent information can be sent directly to the administrator's mailbox in a push mode, prompting administrators.

In this article, a healthy building management system based on business intelligence built in actual projects would be introduced as an example to illustrate the application of business intelligence technology in the entire system.

This building is a complex, contains office, commercial, and club. A healthy building management system has been implemented to collect real-time of indoor air quality data, as well as water quality of swimming pool, recovered gray water and portable water. With its assist, building managers can be advised to take appropriate measures to reduce or minimize indoor air pollution sources, in order to establish and promote the clean air plan to protect the health of residents.

The large area in public buildings, the more complex systems it is, especially HVAC and electrical systems. Ordinary methods is costly, inefficient and cannot manage every details in building. Only building automation (BA) system can meet the requirement of large-scale building management. By reserving data interfaces at the application layer. This system can be used as a building environment management function module for BA system. BA can collect the monitoring data in the device network, so that the BA system can be expanded into a building energy consumption and indoor environment quality parameter data management information system. Instead of logging multiple systems repeatedly, managers can monitor building operation in one system, to monitor real-time energy consumption and environmental quality parameters, data storage, historical reports and other works.

The general users can access this monitoring and management system through various ways such as personal terminals and mobile terminals, to find out real-time environmental qualities in the area. Property managers can conduct real-time monitoring of buildings through advanced authorizations, respond unexpected situations in accordance with routine plans, and realize the meticulous management of people-oriented building operations. On other hand, the workload of management and maintenance can be greatly reduced, work efficiency is improved, and management costs be dropped. Data analysts can use the senior administrator's authorization to log in to the System backstage for software maintenance and alarm management. Through a variety of alarming measures, every system can cooperates with each other and implements comprehensive management in the form of a network. Various emergencies can be handled quickly and decisively.

### 3.1. Graphical interface

Different from the traditional building management system, this system is for the general individuals who lack of professional knowledge. Therefore, it does not use simple data tables to pile up and display. Instead, these data is processed, analyzed, and then displayed to users in a most intuitive way.

For instance, the produce to show the indoor air quality in an office area is: all IAQ related data such as PM$_{2.5}$, PM$_{10}$, CO$_2$, and TVOC concentration shall be select according to an user-defined date range, then an AQI index be calculated in a pre-defined function, finally, this calculated number is mapped to a color shown in Figure 1.
This procedure is automatic and can be real-time (based on-line data instead). Users can aware the most recently air quality only based on color and without any more thinking or mapping. When the color of a certain area gradually changes from yellow to red, it indicates that the indoor air quality has started to deteriorate, requiring the staff to turn on the equipment to ventilate and ventilate the air in time to avoid symptoms such as physical discomfort of the indoor staff.

3.2. Data analysis
In order to facilitate the needs of data statistics and analysis, the system includes a data analysis system. Users can query the change of building operating parameters, such as indoor air quality, water quality, energy consumption, etc., in any area at any time according to their needs. Among them, through the comparison of external weather data with indoor environmental parameters, the user can quickly understand whether the building operation is normal. The query interface is shown in Figure 2.
3.3. Equipment linkage
There are a lot of harmful gases in the exhaust gas from the car start. Since the air flow in the underground garage is limited by the limited entrance of the basement, it is difficult to achieve natural ventilation. Therefore, a comprehensive ventilation system must be set to promptly reduce the concentration of harmful substances. Dilute below the required specification.

Based on the data collected by the carbon monoxide concentration sensor installed in the garage and monitored by building automation system (BAS) and set up an automatic alerting value for the linkage and opening of the garage exhaust fan, the goal of saving labor costs and effectively ensuring air quality can be achieved.

3.4. Monthly report
Based on the collected building operational data, the system will automatically generate a public area environmental monitoring report monthly. In this report, not only the water quality of the month (turbidity, residual chlorine, pH, conductivity) but also the indoor environment quality data of the public areas, as well as the energy consumption in a Sankey chart are summarized to assist the managers in establishing a flexible combination of indoor comfort and building energy consumption. Equipment management system. The report interface is shown in Figure 3.

3.5. Weather Information
In the case of Internet connection, the system can automatically obtain local weather data and provide real-time weather information services to remind residents to increase or decrease clothing according to weather changes and reduce the possibility of outbreaks of infectious diseases such as colds.

4. Conclusions
Building Automation Systems (BAS) have been widely implemented with the development of smart building technology. With its aid, building performance data can be generated, collected, managed and maintained automatically. Energy consumption analysis is performed by energy managers using BASs, which can be regarded as Decision Support Systems instantiated to the energy management domain [8]. However, the key information are under covered by huge number of data. To solve this problem,
business intelligence (BI) technology has been selected. BI technology can extract the desired information from massive building operation data in many ways, such as chats, colors, shapes, etc.

A real building management system for healthy building is introduced in this paper. This system can collect online indoor air quality index as well as water qualities. With persevered data interface, it can be invoked as a function module of BAS, transport data to BAS, to achieve equipment linkage. By implement BI techniques, all displayed data is processed, analyzed and user-friendly. Ordinary users who lack of professional knowledge can detect their surroundings much easier. After a month use, high evaluation are set for this system though there are further work to do.

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