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The Application of IoT Technology in Energy Management of Intelligent Building

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Abstract

At present, the construction energy consumption accounts for 30% of the total energy consumption of the city, and this data also has the tendency to rise, therefore, the building energy saving becomes the object that the relevant scholar focuses on. There are many ways of building energy saving, is one of the most critical to building the scientific management of energy, and in this paper, the research content is the application of Internet of things technology of intelligent building energy management, the purpose is to provide a good reference for energy saving. Building energy management system is the basis of precise metering, energy consumption is the key management scheme design, the core is the analysis of the measurement data, based on energy consumption measuring, management solution and to study the way of accessing data processing platform, analyses the power component measurement, clarification of water supply and drainage, HVAC itemized metering and renewable energy metering, designed by computer room air conditioning monitoring and BAS energy management solutions of solar photovoltaic power generation system, it is concluded that the EMS integration of overall scheme, and based on this, advances the scheme of BAS and the integration of EMS. The implementation of the scheme effectively, in order to make the management of intelligent building energy management system is also energy consumption data of Internet access was studied, in order to lay a foundation for the realization of the Internet of things technology.

Keywords: *Access, Building Energy Consumption, Internet of Things (IoT) Technology, Itemized Measurement, Management Plan*

1. Introduction

It is of great significance to develop energy-saving system of buildings, especially the energy saving system of large buildings. There are many ways of building energy conservation, among which, exploring new energy and renewable energy sources is one of the ways, and another way to effectively manage the energy of buildings is to save energy. The establishment and application of the Internet of things will enable the independent and decentralized computing devices of physics to connect through the network to realize the functions of intelligent identification, positioning, tracking, monitoring and management. This paper explores the application of IoT

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technology in intelligent building energy management system.

The application of IoT technology in building energy management has been studied by many people. Among them: Liang Zhao based on the STM32 processor designed a model which has the function of the configuration of general IoT gateway, implements the perception layer between the sensor network and data center server protocol conversion, data interaction, etc. (Zhao, 2014). Qian Tao based on Internet of things technology, design and development of the building energy dynamic supervision system, realized the energy consumption of electricity, water, warm, natural gas and other real-time data acquisition and management, according to the actual situation of the building, in a variety of data analysis and calculation, on the basis of the formation of the evaluation of building energy consumption, through the establishment of comprehensive energy saving measures, reduce building energy level (Money, 2013). Xiao-man Wang, such as regulatory problems, the energy consumption in buildings is put forward based on SOA architecture, energy regulation system based on Internet of things technology platform, according to the special requirements of building energy consumption regulation, based on wireless sensor technology as the main means of Internet information technology, to realize the remote real-time monitoring management of electricity system to building effective collection, storage and analysis of energy consumption, improve the level of the regulation of building energy consumption (Wang, 2011).

In this paper, on the basis of previous studies, in order to improve the level of regulation of building energy consumption for the purpose, discussed the principle of building energy itemized metering designed ESM and BAS fusion energy management solutions, this paper introduces the energy consumption of building database and the connection between the way the Internet of things platform.

2. Integration of Intelligent Building Energy Management System with the Internet of things

Yongpan Chen pointed out that based on online perception of building energy systems of all kinds of physical quantities, by heterogeneous network fusion diagnosis and feedback control, information gathering, decision-making, implementation of building energy system detection, control and management of the Internet of things is called a IoT building energy system (Chen, 2011). Hong Zhang points out, such as the Internet of things is through the radio frequency identification, sensor, information such as global positioning system, laser scanner, sensing equipment, according to the agreement of the agreement, will any items to connect to the Internet, information exchange and communication, in order to realize intelligent identification, location, tracking and monitoring and management of a network (Zhang , 2012).

In order to adapt to the development of The Times, the building energy management will become the main content of the intelligent building integrated management, and all can use related comprehensive, coordinate and control system, unified management to improve the running efficiency of system energy consumption of buildings, reduce energy consumption, as shown in Figure 1 the structure of intelligent building energy management system:

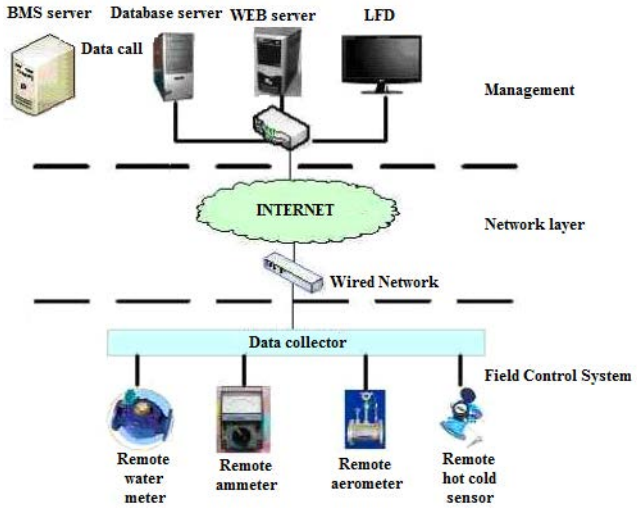


Figure 1. Schematic diagram of intelligent building energy management system.

As can be seen from figure 1, the structure of intelligent building energy management system is divided into management, network layer and site layer. Site layer includes various kinds of field devices, sensors, actuators, and a variety of smart meters, smart meters are among those water meter, electricity meter and gas table, etc., the layer of communication generally adopt fieldbus

standard, more commonly used is RS485, M - BUS, etc. The network layer is a communicating bridge between management and the site layer, upload the layer data collected information to management, at the same time will be issued the management layer motion commands sent to the scene, let the scene operating equipment to perform the corresponding instructions. Gui-wen liu (2012) pointed out that, on the basis of equipment on site management is unified monitoring, control and management, at the same time will field produced by the equipment operation data stored in the server, to record equipment daily operation log and print failure alarm information, etc. (Red, 2012).

Zhang Gongzhong pointed out that the Internet of things is something connected to the Internet, the oil three layers of meaning, first, the core and foundation of the Internet of things is still the Internet, is based on the Internet of the extension and expansion, the architecture of the second, the client, extend and expand to the object to realize information exchange and communication between objects and objects, the third, which implements the contact person's (Zhang, 2010).

The influence of Internet of things on intelligent building technology is everywhere, mainly in the following two aspects:

1. the device is connected by the sensor network.
2. the TCP/IP network platform supports most of the subsystems.

Many subsystems have, as it were, quasi IoT form or is the Internet of things, such as: construction equipment monitoring, video monitoring, entrance guard, IC card, three tables far eastone, intelligent household and professional application system, etc. The intelligent building device sensor network is connected with the following four factors:

1. one-way/two-way.
2. one-way/multi-way.
3. TCP/IP network, non-tcp/IP network.
4. there is no direct interaction/direct interaction between devices.

Different ways of sensor subsystem equipment networking may be different, the two-way, multiplex, the TCP/IP network, direct interaction between equipment mode of sensor networks is more complex, construction equipment monitoring system involves sensor networks would fall under this category. Therefore, the introduction of Internet of things technology into the macroscopic building energy consumption management will have the effect of energy saving to a certain extent.

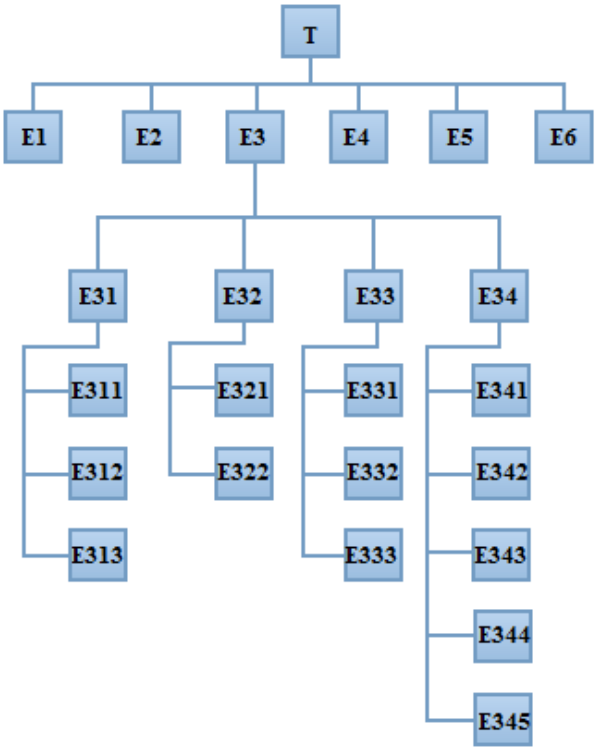
3. Analysis of Building Energy Consumption Separation Measurement Method

For intelligent building, intelligent system itself is quasi IoT structure, therefore, when management platform to build up the Internet of things, from perception layer from scratch, should give full play to the role of the intelligent system. The use of IoT technology to realize the macro-management of building energy consumption in intelligent cities is based on the detailed management of building energy consumption. According to the set of housing and urban-rural development of the state organ office buildings and large public buildings energy consumption monitoring system to share guidelines for the energy consumption data collection technology, building energy consumption measurement classification breakdown is shown in Figure 2.

3.1 Measurement of Power Consumption, the Measurement of Water Supply and Drainage, and the Measurement of HVAC

The power measurement distribution can be divided into four items according to the lighting socket, air conditioning, power and special electricity, and the various electricity items have been classified in detail in Figure 2. Among them, the electricity of E321 cold and heat station can be divided into: cold machine, freezing pump, cooling tower, cooling pump, hot water circulating pump and electric boiler; E322 air conditioning terminal can be divided into: air-condition box, new air unit and fan coil.

Therefore, the measurement of electricity consumption can be divided into four categories: variable distribution, measurement of lighting system, electricity measurement of air-conditioning system and measurement of power system.



T. Total energy consumption of buildings.
E1. Other energy consumption (coal, oil, renewable resources, etc.).
E2. Water consumption. E3. Power. E4. Gas volume.
E5. Heat consumption in central heating.
E6. Concentration of cold consumption.
E31. Lighting socket power. E32. Air conditioning electricity.
E33. Power consumption. E34. Special electricity.
E311. Lights and electrical outlets.
E312. Corridors and emergency lighting.
E313. Outdoor landscape lighting electricity.
E321. Hot and cold stations use electricity.
E322. The end of the air conditioner.
E331. Lift electricity. E332. Ventilator electricity.
E333. Water pump electricity. E341. Information center electricity.
E342. The laundry. E343. The kitchen restaurant has electricity.
E344. Pool electricity. E345. Gym electricity.

Figure 2. The structure of the energy measurement classification structure.

The measurement of water use in water and drainage system is divided into three aspects: cold water system, hot water system and direct drinking water system.

1. the water cooling system of municipal to the introduction of water pipe set on total water meter measurement, meter measuring each individual buildings set points, and main public areas according to the functional areas set up separate metering device.
2. hot water system: centralized hot water supply construction combined with the distribution of water level and water circulation way to set up the supply and return water heat meter measurement, functional area clear construction according to the economic accounting unit sets the metering device.
3. direct drinking water system: set up metering devices on the water treatment equipment of the direct drinking water system.

HVAC itemized metering of heat meter is the main device, and the heat meter is by the flow sensor, heat sensor, and an integrator, used to measure and display the flow through the heat exchange system heat release or absorption values. HVAC itemized metering metering device, can be divided into: centralized heating system meter gauge set meter gauge set, split type air conditioning system, measuring meter setting central air-conditioning systems, refrigeration station meter gauge Settings and boiler and heat exchange station meter gauge set.

3.2 Measurement of Renewable Energy

The application of intelligent building new energy mainly solar and geothermal energy, based on the monitoring and control system for ground source pump as an example, ground source heat pump is a kind of using shallow geothermal resources that can both heat and be refrigerated new energy application system.

Ground source heat pump system according to whether closed circulating water system can be divided into closed loop and open loop system, among them the main form of the former system has soil buried pipe and installation of surface water heat exchanger, the latter way of direct extraction of groundwater and surface water, the treated water quality, groundwater or surface water delivery to the user. The structure of the ground source heat pump system is shown in Figure 3.

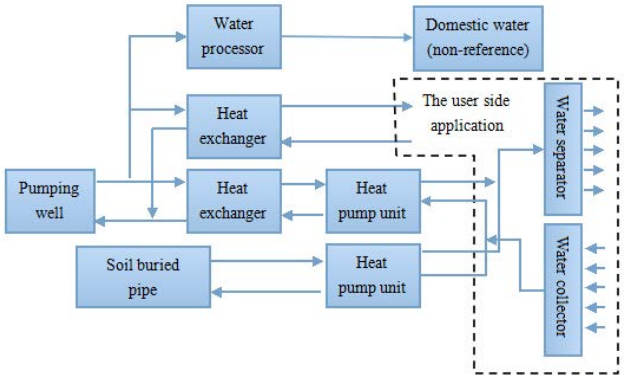


Figure 3. Schematic diagram of ground source heat pump system.

Ground source heat pump control system principle as shown in Figure 3 and Figure 4 shows that the geothermal water pumped from geothermal well through the heat exchanger, to provide users with heat, geothermal water can also be through the heat exchanger heat transfer, and then through the heat pump units provide users with heat source after heat exchange.

According to the user side of the water supply and return water temperature to control the flow of pump size, when the direct digital controller after receive the signal from the temperature transmitter, the degree of preprogrammed, produce the control signal to adjust the operating power of pump. According to the water heater and water temperature and water segregator water temperature to control the water source heat pump units of the secondary side of the plate heat exchanger of the rev. Stop, when the temperature of the water segregator, under temperature difference value to set data value limit or both, is run a heat pump units, when the temperature of the water segregator reached set value on the floor or temperature difference value reached set value, the two stage heat pump units.

The setting of measurement sensor of ground source heat pump monitoring system is as follows:

1. a circulating water flow sensor is installed at the total inlet of the reservoir.
2. set up a circulating water flow sensor on the user side.
3. a water temperature sensor is installed at the total inlet and outlet of the heat source.
4. a water temperature sensor is installed at the user side of the total and out of the water pipe.
5. set an energy meter in the ground source heat pump unit and circulating pump distribution terminal.

System heat source side inlet and outlet pipe of each always set up a water temperature sensor, used to calculate the difference in temperature between inlet and outlet, and coupled with total heat source side inlet pipe set of circulation water flow sensor, hot water flow through the system can be calculated by passing energy, which is of energy consumption system itself, by the same token, the user layer of total inlet and outlet pipe sensor, the heat released by the heat, can calculate the system is the total energy used by the user.

Through the above on perception layer of itemized metering meter and renewable energy to provide energy meter gauge set, can realize building energy consumption is itemized metering and monitoring management of renewable energy, realize the refinement of building energy management and comprehensive management.

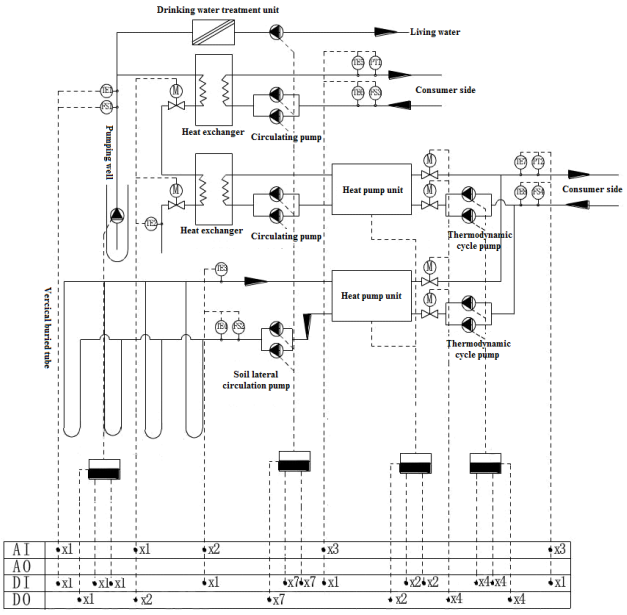


Figure 4. Schematic diagram of ground source heat pump monitoring system.

4. The Integration of BAS Energy Management Solutions and EMS Energy Management Solutions

4.1 BAS Energy Management Plan

BAS energy management plan refers to the energy management scheme based on construction equipment monitoring system, can be used to direct digital controller the building equipment to monitor the

running status and operation parameters, also can use monitoring data in construction equipment management system development energy management services. On the BAS development function of itemized metering, energy consumption will be itemized metering of energy consumption of BAS is connected to the BMS server, finally uploaded to the Internet of energy management platform, the BMS server here refers to the construction equipment management system server. BAS energy management scheme design based on intelligent building itself has the building equipment monitor system, and apply new energy system into the building equipment monitor system, through BAS sensors implementation power, water and heat metering, this paper takes computer room air conditioning power consumption measurement as an example for analysis, and to solar photovoltaic power generation system has a perfect measurement as an example to analyze the energy consumption of BAS renewable energy metering.

Computer room monitoring work process: cooling (heating) system to provide air conditioning cold (hot) water, chilled water system through the frozen water pump and pipeline will be frozen water to go out for the use of air conditioning users, after use of air conditioning water returned to the evaporator, recycled after cooling, cooling water system is mainly refers to the system of cooling water pump, cooling tower, cooling water after cooling tower cooling recycling use. Its monitoring principle is shown in Figure 5.

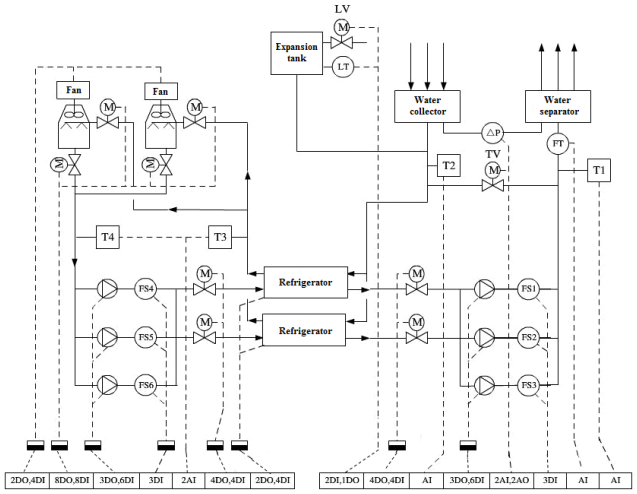


Figure 5. Monitoring schematic diagram of air conditioning main room.

The types of monitoring points in figure 5 are shown in Table 1.

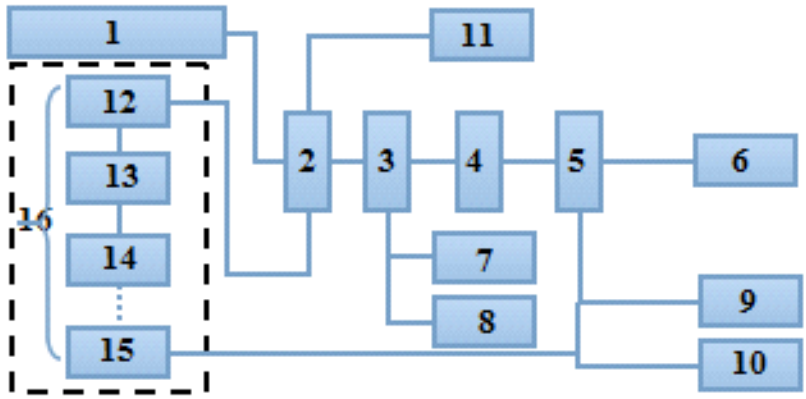
Table 1. List of monitoring points of air conditioning main room

Monitor dot	type	Monitor dot	type
AI	Chilled water supply flow (temperature) detection	2AO	Freezing water pressure difference bypass regulation state
2AI	Cooling tower inlet and outlet water temperature detection	1DO	Expansion tank solenoid valve switch control
2DI	Water level test of expansion tank	2DO	Cooling tower fan motor operation and fault state
3DI	Water level test of expansion tank		
4DI	Cooling tower fan start and stop control	3DO	Operation and fault status of cooling water pump
6DI	Starting and stopping control of cooling water pump	4DO	Switch status of water valve in chiller unit
8DI	Start and stop control of cooling tower inlet valve	8DO	Starting and stopping state of cooling tower inlet and outlet valve

The solar photovoltaic power generation system consists of solar cell components, batteries, protectors, inverters, ac distribution cabinets, load and solar tracking devices, and its system structure is shown in Figure 6.

Solar photovoltaic power generation system by solar energy battery simulation by solar energy controller through the battery charging, when battery charging after reaching upper limit voltage value, performed by the controller automatically stop charging, disconnect the solar battery charging circuit simulation, when the battery voltage is lower than the upper limit voltage, to charge the solar cell phalanx access charging circuit. At the same time, the power supply is provided for the dc load in the building through the dc distribution plate.

The monitoring principle of solar photovoltaic power generation system is shown in Figure 7.



1. Single silicon solar battery pack;
2. Controller;
3. Dc switchboard;
4. The inverter;
5. Ac switchboard;
6. Ac power grid;
7. The dc load;
8. Dc load;
9. Exchange load;
10. Exchange load;
11. Batteries;
12. Stepping motor;
13. The driver;
14. Level converter;
15. Control the host;
16. Solar automatic tracking device

Figure 6. Schematic diagram of solar PV system structure.

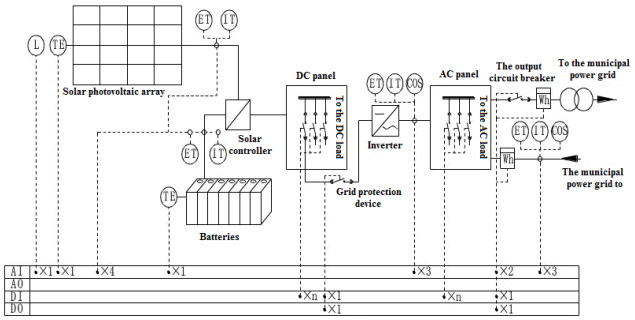


Figure 7. Monitoring schematic diagram of solar photovoltaic power generation system.

Direct digital controller implement collection of outdoor light intensity, reflects the stand or fall of outdoor lighting, solar photovoltaic array part of absorption of solar radiation into heat energy in the process of work, raise the temperature of photovoltaic cells, direct digital controller to collect the temperature and set the alarm limit, when the temperature exceeds a certain value when the alarm, to remind managers make corresponding processing. The solar PV power generation is monitored and controlled in real time by the monitoring system, and the energy collection maximization, energy use safety and electrical energy output are qualified.

4.2 EMS Energy Management Plan

EMS energy management solutions is independent of the energy management system, the building EMS as a subsystem, integrated into the building in the BMS, access to the Internet through BMS management platform in energy management platform, to provide data for the construction of Internet of energy management platform. The structure of EMS structure can be divided into three parts: perception layer and transport layer. The structure of EMS structure is shown in Figure 1. If as an independent system, energy management system of building energy consumption statistics, and the lack of control and management of building energy consumption equipment, only stay in the level of the statistical data of energy consumption, the meaning of building energy efficiency is not big, the BMS system can realize intelligent buildings and interoperability between the intelligent subsystem linkage control, etc., can according to the results of the statistical analysis of energy consumption optimization control energy dissipation devices.

Intelligent building energy management systems and intelligent building other subsystems may use different types of data communication protocol, using OPC technology to make the user can through consistent interface for data access and integration to unified BMS management platform for data analysis and management of these systems usually adopt a RS232 and RS485 communication protocol, BACnet, LonWorks, the Network API, Modbus, SDK, DDE, what kind of agreement, whether based on access integration platform can use OPC technology.

If able to energy management system integrated into the BMS platform, through the platform of Web technologies can access of the intelligent building energy management system, read the energy consumption of the energy management system data information, analysis processing, through the role of the construction equipment monitoring system to control and manage the equipment, so as to realize information resources sharing between each subsystem and unified control management. The overall plan for integrated energy management systems as shown in Figure 8.

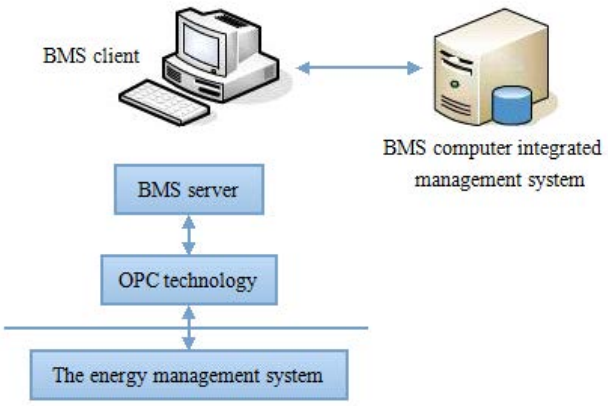


Figure 8. The overall package of EMS integration.

4.3 The Network Architecture Integrated with EMS

Construction of electric power parameter measuring instrument, instrument such cold heat meter, water meter, temperature sensor is through wired or wireless way, EMS server to connect to the perception layer, integrated into the BMS server, and realizes the perception layer and IoT energy management platform of reliable connection. The ideal way of network architecture is the combination of wired and wireless connection, as shown in Figure 9, the network schematic diagram of the integration of BAS and EMS.

The BAS and EMS energy management solution, which can be collected from the BAS data server, avoids repeated measurements. EMS and BAS share bus network and network controller, save investment, energy management system will be analyzed based on energy consumption data, and can adjust BAS parameters to meet energy saving targets.

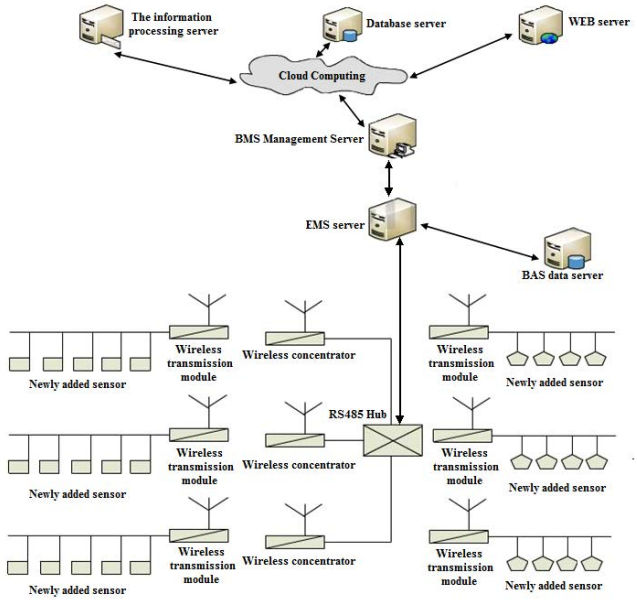


Figure 9. The network architecture diagram of BAS and EMS.

5. The Internet Access Method of Intelligent Building Energy Management System

This paper summarizes three kinds of Internet access methods of energy consumption data of intelligent building energy management system: OPC mode, Web Service mode and ODBC mode respectively. The four types of access methods are discussed in order to lay the foundation for the intelligent building management system access to IoT energy management platform.

1. The OPC interface has a custom interface and the automation interface of two types, the former can be used high-level programming language such as c + + or vc + + to develop OPC server client application, while the latter is based on the scripting language standard interface, you can use the VB, Delphi, Power Builder, and other programming languages. By OPC data access technology, Internet data platform cannot through the BMS integration platform, only need to access the BMS each subsystem of OPC server can be realized to the underlying data collection, as shown in Figure 10 for database access based on OPC technology.

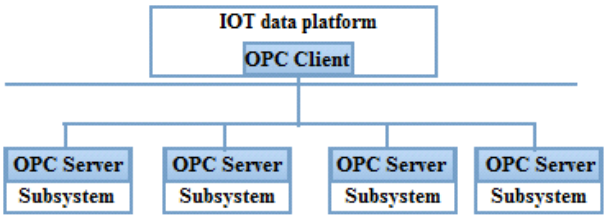


Figure 10. Access to the OPC server.

2. Web Service platform by the SOAP, UDDI and WSDL three elements, including SOAP defines an xml-based extensible message format, the envelope is a simple xml-based protocol, it USES the program via HTTP to exchange information; UDDI is a directory service, a protocol for publishing and searching WEB services that can be used by the application to find the target WEB service at design or runtime; WSDL is an XML format document that is an xml-based language for describing Web services and how to access the Web Service. The XML based data transmission is divided into three steps:

Step 1. Convert the data information that needs to be transmitted on the BMS platform to the data format of the XML document.

Step 2. The XML document is passed between the two.

The IoT data platform receives the XML document data and converts it to the data format it needs.

A simple model based on XML data exchange between two applications is shown in Figure 11.

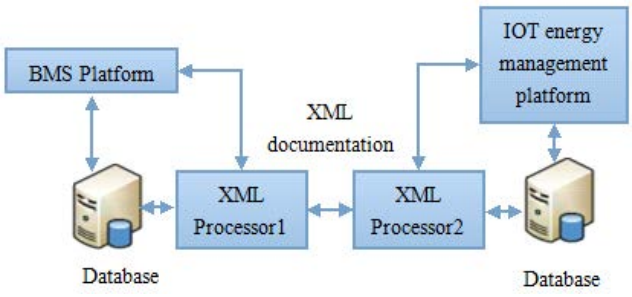


Figure 11. A simple model based on XML data exchange.

Figure 11 is the function of XML processor 1 to BMS in the platform database need to transport the energy consumption data into XML format documents, XML data format conversion, form a unified standard, XML documents sent to Internet data platform. The function of XML processor 2 is to accept XML documents from the BMS platform and to extract and process data according to their own needs.

3. When system integration is performed using ODBC technology, different network modes can be used flexibly according to the size of the system and different requirements. An ODBC driver is a special call to a special database in which an application dynamically links to a specific database. Structured Query Language (SQL) is a relational database using standard language, is used to retrieve, update, and manage data, ODBC is Microsoft's standard public application programming interface, is used to access, display and modify a variety of relational database data, system integration platform software through the ODBC API to access third-party SOL data source, this approach will only building BMS, real-time and historical data included in IoT perception layer, and its principle and intelligent building BMS level of OPC data access is the same, using C/S model, but different in the ODBC data access only BMS building database abstraction into an underlying devices, as the data source of Internet application services. See Figure 12 for ODBC access to the BMS database.

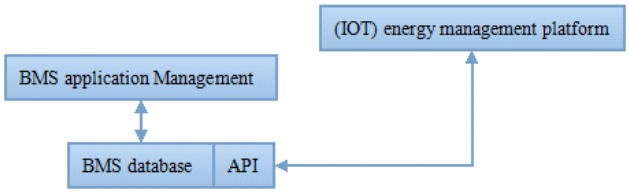


Figure 12. ODBC access to the BMS database.

Applying BMS system ODBC technology to access the Internet of things energy management platform, database need to provide the interface data details, including the database table and field in detail, according to the agreement to develop the corresponding system communication driver, the driver after the test pass, variable mapping according to the content of the agreement, according to the site information point distribution configuration for unified monitoring interface.

6. Conclusions

This paper summarizes the intelligent building energy management system and Internet integration, on the basis of it is concluded that in order to adapt to the

development of The Times, building energy management will become the main content of intelligent building integrated management, and can use all with relevant comprehensive, coordinate and control system, intelligent building energy management system is the basis of accurate measurement of building energy consumption, the key is management scheme design, and chartered management solutions, intelligent implementation requires a IoT energy management platform.

1. this paper focuses on the measurement of electricity consumption, the measurement of water supply and drainage, and the measurement of HVAC, and the principle of the metering system of renewable energy is studied in the case of ground source heat pump system.
2. in computer room air conditioning monitoring work processes and solar photovoltaic power generation system as an example, this paper expounds the BAS energy management solutions, in the study of EMS energy management solutions, got the overall scheme of the integration of EMS, and on the basis of the research put forward the scheme of BAS and the integration of EMS, analyzes the integration of the two-network architecture.
3. for intelligent building energy management system energy consumption data of Internet access, this paper analyzes the three access modes, the OPC server access is obtained, the simple model of data exchange based on XML, and ODBC database access to BMS.

7. Acknowledgement

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7. Zhang, G. (2010). Smart architecture and Internet of things. *Industry bbs*. 117, 39–40. On the financials its balanced approach is supporting sequenced investment in value accretive growth and considerable long term business improvement, alongside attractive shareholder returns. It has delivered $10.3 billion in cash returns to the shareholders since 2017 and $4 billion in H2 2021 alone. Its ongoing investment in the business also supports its emissions reduction objectives and it therefore expects a normal cycle of capital investment to continue to fund the majority of the operationaldecarburization projects.
8. Mark Cutifani,Anglo's CEO added: "Anglo American offers an increasingly differentiated investment proposition centred around sustainable performance and high quality, responsible growth. Combined with its integrated approach to technology in pursuit of the safer and more sustainable supply of materials essential to the energy transition and growing consumer demand patterns, we are well positioned to meet the expectations of itsfull breadth of stakeholders across society."