Research and Realization of Intelligent Building Energy Management System

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Abstract: Nowadays building energy consumption occupies 30% of overall urban energy consumption, which presents rising trend. Therefore building energy conservation becomes an important focused object by relevant scholars. Building energy conservation has many ways in which the most essential is scientific management on building energy. This paper does researches on energy management problems of intelligent buildings utilizing Internet of things technology thus providing good references for building energy conservation. Basis of building energy management system is precise measurement of energy consumption. The key is design of management scheme. Core is analysis on measurement data. This paper does researches on energy consumption measurement, management scheme and access mode of data processing platform, designs BAS energy management scheme based on air conditioning host machine room monitoring and solar photovoltaic power generation system, acquires overall scheme of EMS integration and proposes the scheme combining BAS with EMS. For the purpose of achieving effective implementation of management scheme, this paper also does research on Internet of things access mode of energy consumption data in intelligent building energy management system thus laying foundation for realization of Internet of things technology.

Key words: Building energy consumption, Sub-metering, management scheme, Access mode, Internet of things technology

1. INTRODUCTION

Development of building energy consumption system especially energy consumption system of the large building has great significance on energy-saving strategy of our country. There exist many ways for building energy conservation. One of them is exploring new energy and renewable energy resources. In addition, effective management on building energy namely scientific energy conservation is also useful. Construction and application of Internet of things connects the separated and decentralized computing devices in physics through network thus realizing functions of intelligent identification, localization, tracing, monitoring and management. This paper is aimed at exploring application of Internet of things in intelligent building energy management system. In terms of application research on Internet of things technology in building energy management, many people have made great efforts. Among them, Liang Zhao and others designed one universal Internet of things gateway with self-configuration function on the basis of STM32 processor in 2014, which realizes protocol conversion and data interaction between perceptual sensor network and data central server (Liang Zhao, Jili Zhang, Ruobing Liang, 2014). in the literature (Yu Feng Qin, Tian, Bei, Zhang Xin, Wang Qiang, Yu Dan Shi and Zhao Rang, 2013), monitoring and management system of building energy consumption based on Internet of Things technology architecture, in the system, various energy instrumentation is installed inside the building and measurement all kinds of energy consumption data in the perception layer, collection daternital data connected to the RS485 bus access gateway for data transmission via Ethernet or mobile communication network in the network layer and transport layer, deal with the statistical analysis of the energy consumption data in the application layer. The system has been successfully applied to more than 50 large-scale public building to implement energy consumption monitoring and management, and the support of the underlying data for building energy efficiency. In the year of 2011, Xiaoman Wang and others proposed one energy consumption monitoring system which is aimed at building energy consumption monitoring problem, keeps SOA as architecture and has Internet of things be platform. According to special requirements of building energy consumption monitoring, it utilizes Internet of things information technology which is wireless sensor technology oriented thus realizing remote monitoring and management on electric energy in real time. This system would do effective acquisition, storage and analysis on building energy consumption, which improves monitoring level on building energy consumption (Xiaoman Wang, Junqi Yu, Bochao Gao and Qi Lv, 2011).

Based on researches of predecessors, this paper discusses sub-metering principle of building energy, designs energy management scheme combining ESM with BAS and introduces connection type between building energy consumption database and Internet of things platform for the purpose of increasing building energy consumption monitoring level.
2. INTEGRATION BETWEEN INTELLIGENT BUILDING ENERGY MANAGEMENT SYSTEM AND INTERNET OF THINGS

In the year of 2011, Yongpan Chen proposed that the Internet of things which is called Building Energy System Internet of Things realizes detection, control and management on building energy system through heterogeneous network integration, information aggregation, decision diagnosis and feedback control on the basis of online awareness on various physical quantities in building energy system (Yongpan Chen, 2011). In 2012, Hong Zhang and others proposed that Internet of things is a kind of network which does information exchange and communication by connecting any item with Internet through information sensing devices of radio frequency identification, sensor, global positioning system and laser scanner and according to stipulated protocol thus realizing intelligent identification, positioning, tracing, monitoring and management (Hong Zhang, Na Wang, Weilin Sang and Hongxia Li, 2012).

In order to adapt to epoch development, building energy management would become important content of building intelligent integrated management, which would does synthesis, coordination and control on all relevant energy-using systems. Its unified management improves operating efficiency of each building energy consumption system and reduces energy consumption. Fig. 1 shows the structure of intelligent building energy management system.

![Figure 1. Structure Diagram of Intelligent Building Energy Management System](image)

It is seen from Fig.1 that structure of intelligent building energy management system is divided into three parts of management layer, network layer and field layer. Field layer includes various field devices such as sensor, actuator and all kinds of intelligent instrument. Intelligent instrument also includes water meter, electricity meter, gas meter, etc. Field layer communication generally utilizes field bus standard in which the frequently-used are RS485 and M-BUS. Network layer is Intercommunication Bridge between management layer and field layer, which uploads data information collected by field layer to management layer and sends action command from management layer to field layer thus leading field devices to execute relevant command operation. In 2012, Guiwen Liu and others proposed that management layer does unified monitoring, control and management on field devices. Meanwhile, it stores data from field device operation into server in order to record daily operation log of devices and print alarm information of failure devices (Guiwen Liu and Bei Bei, 2008). In 2014 Qun Du proposed that Things are network extends Internet and traditional communication networks and expand the application that uses electronic tags to physical objects Internet banded together using artificial intelligence techniques to achieve real-time control and precise management of common physical objects. In the era of things, intelligent integration of people, equipment, and information is urgently study. Proposed based networking equipment management system solutions to achieve a gateway system function, electrical controls, security systems, remote control function and environmental control functions (Qun Du, 2014). In the literature (Xiaofeng Hu, 2014), Xiaofeng Hu combined with the key technologies of the Internet of things technology-designed a set of intelligent system for building energy consumption monitoring and management based on wireless sensor network middle-ware. The system achieve the building energy consumption monitoring and rational utilization based on building energy service equipment (such as in lighting equipment, air conditioning equipment etc.) monitoring and management. Energy consumption of the equipment meet the scene of the user for the comfortable environment by change the state of environment, and the user can monitor the running status of all the equipment and environment variable information in the process, and to control energy consumption equipment. In the literature (Chuyuan Wei and Yongzhen, 2011), authors introduced and analyzed the information technology in building energy-saving. For building energy-saving on the demand for intelligent building energy monitoring, proposed a system framework of Building Energy...
Monitoring and Analysis System based on the Internet of things, which has some enlightening in Building energy consumption further to achieve real-time monitoring and control, and improve the energy-saving of intelligent building.

Internet of things influences intelligent building technology everywhere which mainly presents in the following two aspects.
1) Devices do networking through sensor.
2) TCP/IP Network platform supports a big part of subsystem.

It could be said that many subsystems have been quasi-Internet of things morphology or Internet of things morphology such as systems of building device monitoring, video monitoring, access controller, one-card, three meters remote transmission, intelligent home and professional application. Networking way of intelligent building device sensor involves the following shown four factors.
1) Unidirectional or bidirectional.
2) Multi-route or single-route.
3) TCP/IP network or non-TCP/IP network.
4) Indirect interaction or direct interaction among devices.

Different subsystem device sensors keep different network ways in which networking ways of bidirectional sensor, multi-route sensor, non-TCP/IP network sensor and devices’ direct interaction are complicated. Sensor networking way of building device monitoring system belongs to this type. Therefore introduction of Internet of things technology into building energy consumption management on the macro would keep energy consumption effort to some extent.

3. ANALYSES ON BUILDING ENERGY CONSUMPTION SUB-METERING METHOD

Aiming at intelligent buildings, its intelligent system is quasi Internet of things structure. Therefore efforts of intelligent system should be made full use without beginning from perception layer when Internet of things energy management platform is constructed. The basis of utilizing Internet of things to realize macro management of smart city on building energy consumption is elaborate management on building energy consumption.

3.1. Sub-metering of Electricity Consumption, Water Supply and Drainage and HVAC (Heating, Ventilation and Air Conditioning)

Building energy consumption metering classification includes electricity consumption sub-metering, water supply and drainage sub-metering and HVAC sub-metering. Electricity consumption sub-metering includes four aspects of power substation metering, lighting system metering, air conditioning system electricity consumption metering and electric system metering. Water consumption sub-metering of water supply and drainage system includes three aspects which are cold water system, hot water system and drinking water system. Major installation of HVAC sub-metering is heat meter which is composed of flow sensor, heat sensor and integrator, which are used for measuring and showing caloric value released or absorbed by water flow through heat exchange system. Metering device of PVAC sub-metering includes meter set of central heating system, meter set of multi-coupled air conditioning system, meter set of centralized air conditioning system, meter set of refrigeration station, meter set of boiler room and that of heat exchange station.

3.2. Metering of Renewable Energy

New energy application in intelligent buildings mainly includes solar energy and geothermal energy. This paper takes ground source heat pump monitoring system as example to do explanation, which is new energy application system providing not only heat supply but also refrigeration through utilizing shallow geothermal resources.

Figure 2. Structure Diagram of Ground Source Heat Pump System
Set of meter sensor in ground source heat pump monitoring system is shown below.
Set a circulating water flow sensor in the position of main water inlet at heat source side.
Set water temperature sensors in both positions of main water inlet and outlet at heat source side.
Set water temperature sensors in both positions of main water inlet and outlet at client side.
Set both electric energy meters in ground source heat pump crew and circulating pump distribution
transmission end.
Set of meters of perception layer sub-metering and energy provided by renewable energy sources would
realize sub-metering of building energy consumption and monitoring management on renewable energy sources
thus achieving elaborate and comprehensive management on building energy sources.

4. INTERNET OF THINGS ACCESS METHOD OF INTELLIGENT BUILDING ENERGY
MANAGEMENT SYSTEM

This paper proposes three types of Internet of things access methods of energy consumption data in
intelligent building management systems, which are OPC Method, Web Service Method and ODBC Method.
The following content does description on them in order to lay foundation for intelligent building management
system accessing to Internet of things energy management platform.

1) OPC interface includes two types of custom interface and automation interface. Custom interface would
develop client application program of OPC server through utilizing high-level programming languages like C++
or VC++. Automation interface is standard interface based on script programming languages which could utilize
various programming languages like VB, Delphi, Power Builder, etc. Data access of OPC technology leads
Internet of things data platform to realize acquisition of underlying data through accessing OPC servers of each
BMS subsystem without passing by integration platform of Building Management System namely BMS. Fig.3
is the database access diagram based on OPC technology.

2) Web Service keeps three elements which are SOAP, UDDI and WSDL. SOAP is a kind of simple and
extensible message envelope format based on XML, which utilizes program to exchange information through
HTTP. UDDI is a type of directory service which is a protocol for publishing and searching WEB service. Its
application program would find target WEB service when it’s being designed or operated. WSDL is a XML
format file, which is a language based on XML and for describing and accessing Web Service. Data
transmission based on XML is divided into the following three steps.
STEP 1 is converting data information requiring transmission on BMS platform into data format of XML
file.
STEP 2 is transmitting XML file between them.
STEP 3 is that Internet of things data platform receives XML file data and converts it into the needed data
format.
Fig.4 is the simple model of data exchange between both applications based on XML.
Function of XML processor 1 in Fig.3 is converting energy consumption data needs transmitted in BMS platform database into XML format file, doing format conversion on XML data, forming unified standard and sending XML file to Internet of things data platform. Function of XML processor 2 is receiving XML file from BMS platform and doing selection and processing on data according to its own requirements.

3) Different networking methods could be flexibly utilized according to size and different requirements of system when ODBC technology does system integration. ODBC driver is a special call on special database, in which application program would be dynamically linked with a specific database. Structured query language namely SQL is standard language utilized by relational database. System integration platform software accesses to third-party SQL data source through ODBC API. It brings real-time and historical data of intelligent building BMS into Internet of things perception layer. Being similar with OPC data access of intelligent building BMS, its principle is utilizing C/S mode. Fig.5 shows the accessing BMS database by ODBC method.

Bring BMS system access to Internet of things energy management platform through utilizing ODBC technology, which needs provision of detailed database information of interface data including database table, specific field indication, etc. Develop relevant communication driver according to system protocol. After driver test passes, do variable mapping according to protocol content. Unified monitoring interface would be configured based on the field information point distribution diagram.

5. CONCLUSION
On the basis of network integration between intelligent building energy management system and Internet of things, this paper proposes that energy management would become the main content of building intelligent integrated management for the purpose of adapting to epoch development. It also does integration, coordination and control on all relevant energy-using systems. For sake of realizing access of energy consumption data of intelligent building energy management system to Internet of things, this paper does description and analysis on three kinds of access method thus acquiring access method of OPC server, simple model of data exchange based on XML and ODBC method accessing BMS database.

REFERENCES