Available online www.jocpr.com

Journal of Chemical and Pharmaceutical Research, 2014, 6(6):326-329

Research Article

ISSN : 0975-7384
CODEN(USA) : JCPRC5

Research on integration of building automation control system with BAC net based on OPC technology

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ABSTRACT

BACnet protocol with the characteristics of openness, practical and easy integration with other networks is widely used in building automation control system(BACS). In order to make the BACnet building automation control system exchange data with third-part software, an integration scheme of BACnet building control system based on OPC technology is designed. Implementing that BACnetMS/TP collects real-time data from building automation equipment and transform it into the OPC standard data type, completing the OPC interface call, so as to satisfy the requirement of the building control system integration. Through factory soft testing, development of BACnet building control system based on OPC technology is feasible.

Key words: OPC technology; BACS; BACnet; integration

INTRODUCTION

BACnet is applied to distributed control object oriented open network communication protocol. Its emergence for building automation equipment data communication establishs a unified standard, and makes the equipment from different vendors can realize mutual communication and on the basis of mutual communication to achieve interoperability.In addition, BACnet provides other services, such as alarm, event service, file management, service object access, remote equipment management and virtual terminal service. In the implemention of building system integration, BACnet protocol data interaction with other protocols is essential,only this real meaning up building system integration can be called. This paper adopts the OPC technology [1,2] to achieve integration. It is used for developing software driver that is application in the Windows platform connected with field control equipment according to the regulations of the OPC fund of OPC specification[3].OPC server[4]as an intermediary is responsible for the data read from the data source and communicates with OPC client. At present most of the building equipment factory manufacturers support the OPC standard, and building control management softwares have OPC client interface [5]. Therefore, the OPC technology can effectively achieve the demand of the building system integration to achieve generalization and modularization.

2. BACnet protocol and OPC technology

2.1. BACnet protocol

BACnet protocol adopts object-oriented analysis and design (OOA&D) advanced method[6,7].The various basic function units are described through BACnet definition and formed to have a general and reusable function of “Object”. In the “Object” a global “Object identifier attributes” is joined to define access or manipulate objects [8] to offer server. BACnet protocol model is simplified to four hierarchy structure—the physical layer, data link layer, network layer and application layer refered to ISO 7 layers of the OSI/RM model [9]. MS/TP（Master-Slave Token Protocol） as BACnet one of data link layer solution,specifically for building automation and control equipment of data links provides communication norms and the network layer interface.MS/TP with its characteristics of good real-time and high reliability widely is used in building automation system.

2.2. OPC technology

OPC,based on the Microsoft Active X, COM and DCOM(distributed component object model)，is a standard instruct tion set of access interface, properties and methods，and it offers the communication standard between the application program upon Windows operating system and process control application. The task of development of access interface is performed by hardware manufacturer or third party manufacturers. Using Client/Server mode,clienteles are provided to the OPC server.As long as manufacturers follow the standard of opc technology,hardware and software of interconnection and interoperability can be achieved.

OPC offers a series of unified data access specification between field control equipment and application program, which ,using DCOM technology,not only can be applied to computer independently, and can support communications among applications on different networks as well as differernt operating systems.It has characteristics of the code reuse, language independence and ease of integration.Due to the fact that OPC standardized interface functions, no matter what conditions the field devices are, the client can be unified access.As a consequence, the transparence of the software to customers is ensured. The research using the OPC DA interface specification developed a data access server,to realize the integrated function of control system based on BACnet fieldbus.

3. Design of building integration system

3.1.The system diagram

Building automation subsystem as BACnet intelligent control node, peer-to-peer communication between nodes are came ture through BACnet definition of the objects, attributes, and service. Security system through its node releases information to the lighting system; water supply and drainage system through its node accepts messages from the variable air volume air conditioning system. Using MS/TP integration network quickly and conveniently to pass and control data，and to finish information interoperability of building control system.Through gateways providing a connection between data and control network ，control network adopts the way that OPC client synchronizes with BACnet field real-time data. The client with OPC interface can also visit the BACnet intelligent control node through OPC service interface, realization of building automation system integration in the broadest sense of the term. The overall diagram of integrated system with BACnetMS/TP [10] building automation system supporting OPC standard is shown in figure 1.

Integrated system is consists of BACnetMS/TP building automation system module, BACnet data-driven module, OPC and BACnet data conversion module, and the OPC service interface module. BACnetMS/TP building automation system module includes subsystems of water supply and drainage, lighting, vav and security. Various subsystems together constitute the building automation module through MS/TP control bus with BACnet star network structure. Intelligent control node monitors the operation station of the building equipment, lighting equipment of switch state, variable air volume air conditioning system of the return air temperature, return air humidity, the new air volume, the indoor temperature, water supply and drainage system of the water tank, tank liquid level, pump frequency conversion device of running status parameters and other building automation equipment.

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BACnet-OPC data conversion module is to design BACnet object model data from drive moduleis to be a reasonable data structure to store, and data are matched with OPC Item.Thus to keep the changes of OPC server object pace with data changes from building automation device is achieved, solving the compatibility problem that the BACnet and OPC standard, and meeting the requirements of the building control system integration.

OPC service interface module provides the OPC client interface functions that are used to access OPC server. Any client with OPC interface can communicate with OPC service interface,which effectively avoids the development of repeatability and improves the system's openness and interoperability.

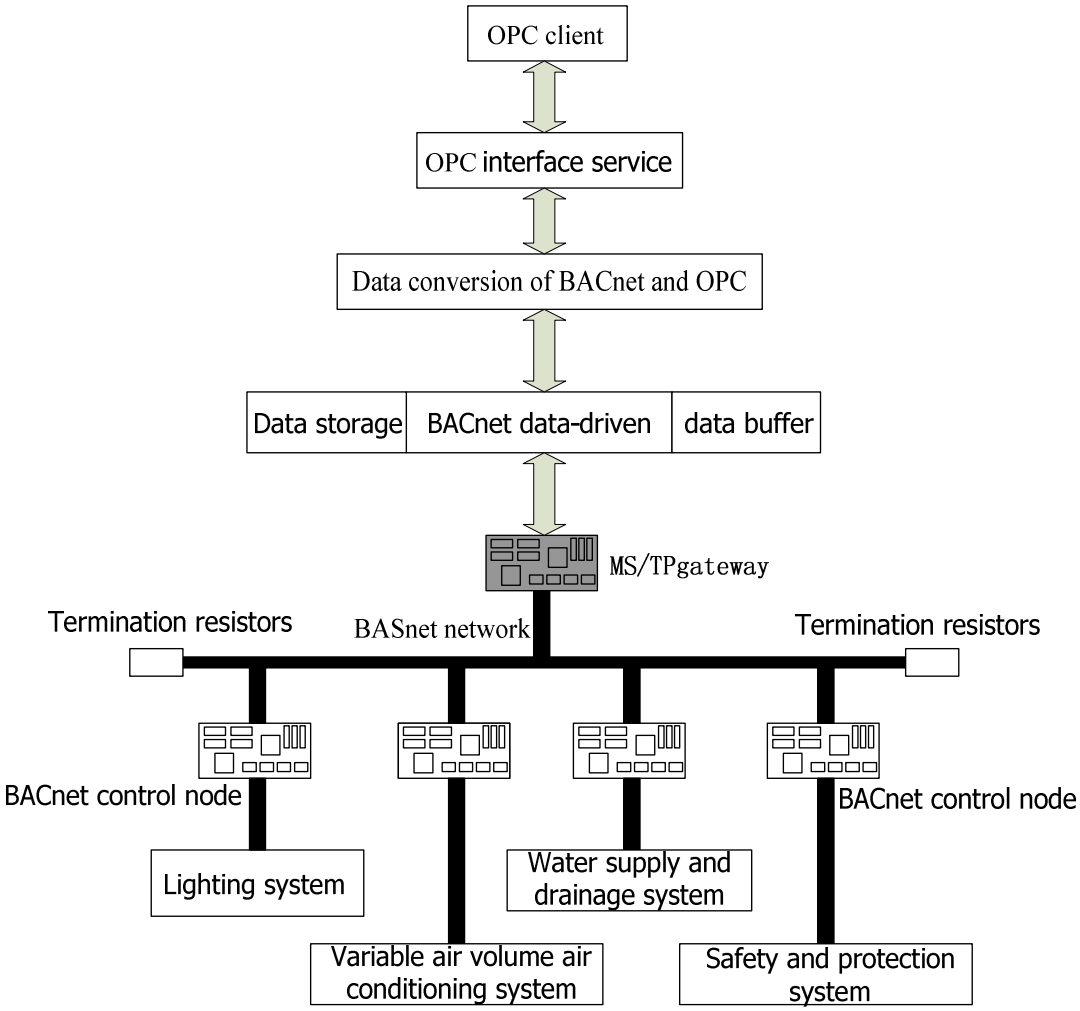

Figure1. The overall diagram of BACnet building control system based on OPC technology

3.2 The integration design of building automation sub-systems

MS/TP network,through the subsystems of intelligent node,achieves channel sharing and communicates with each other in the form of transferring token. According to the feature of each subsystem and its practical application in engineering, integration decision-making relationship is shown in figure 2.

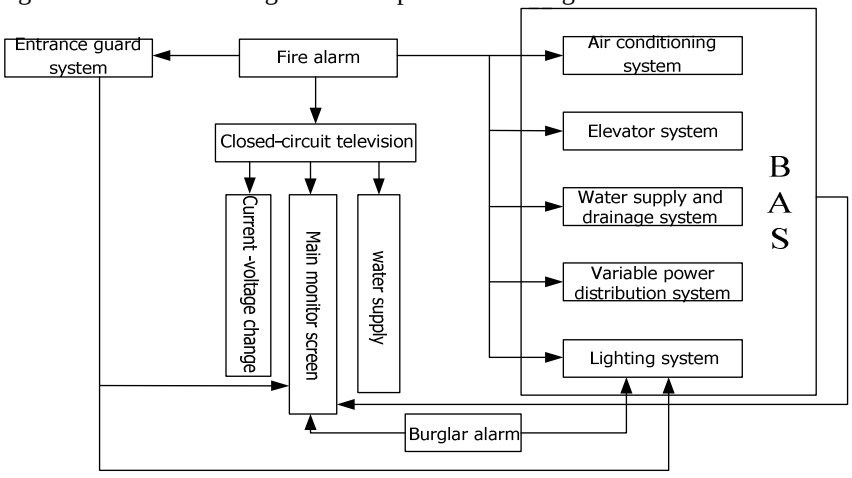

Figure2. Integration decision-making relationship of BAS

In the picture,direction of the arrow indicates that a subsystem action of BACnetMS/TP intelligent control node affects the other subsystems and the direction of the role. Subsystem pointed by arrow is the receiver,another side is

the active party. According to the relationship and integration ways interoperability process of BAS equipment is shown in the table 1.

Table1. Interoperability of BAS Equipment

Active side	Data type	Receiver	Data type
Fire alarm	Analog output	Blower	Binary output
Fire alarm	Analog output	Voltage and current	Analog
Fire alarm	Analog output	Water supply	Analog
Fire alarm	Analog output	Elevator control equipment	Binary output
Fire alarm	Analog output	Main monitor screen	Digital input
Fire alarm	Analog output	Entrance guard system	Binary output
BAS abnormal	Analog or digital	Main monitor screen	Digital input
Guard system exception	/	Lighting control box	Binary output
Guard system exception	/	Main monitor screen	Digital input
trespassing	/	Main monitor screen	Digital input

In order to describe the correlation degree and input/output relationship between MS/TP control node of BAS equipment and other equipment control node,stipulate that all data devices that has the function of calculation and processing capacity are depicted as a single neuron. As shown in figure 2.

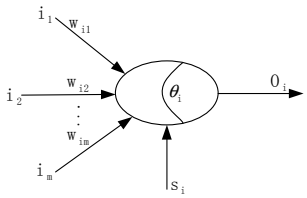

Figure3. Schematic diagram of describing input/output relationship by a single neuron

According to the figure 3, input/output relationship of a single BAS equipment can be expressed as follows:

$$O_i = f\left(\sum_{j=1}^{m} w_{ij} I_j + s_i - \theta_i\right)$$

θ_i is the threshold for equipment, I_j is the input signals for other devices. $j = 1, 2, \cdots\cdots, n$, w_{ij} is the connection weights from one device to another device. s_i is the external input signal, O_i is the output of a neuron,namely the action of one equipment. $f(\cdot)$ is the characteristic of nonlinear function.

According to the characteristics of the building control system in an actual work,define:

$$f(\cdot) = (w_{i1}I_1 \cup w_{i2}I_2 \cup \cdots\cdots \cup w_{im}I_m) \cup S_i - \theta_i$$

"U" means choosing outpu.If $w_{ij} = 0$,no output;if $w_{ij} = 1$,output. In this way, the output of the neuron can be expressed as follows:

$$O_i = (w_{i1}I_1 \cup w_{i2}I_2 \cup \cdots\cdots \cup w_{im}I_m) \cup S_i - \theta_i$$

Connection weights describes whether internal data of neurons chose to transmission outward. if transmission that means integration.if $w_{ij} = 0$,no integration;if $w_{ij} = 1$, integration.

3.3 Design of BACnet data-driven module

BACnet protocol that is dedicated to BAS control system is the open network communication model of object-oriented. BACnet object model is divided into analog input object model (AI), analog output object model (AO), binary input object model (BI), binary output object model(BO), simulation value (AV) object model (AV) , binary value object model (BV), and the device object types（DO）. Additional types include event registration and event enrollment, group , polymorphic input MSI (Multi - state Input) polymorphism and output the oledata,MSO (Multi - state Output), calendar, and time arrangement. According to the above model objects , any building

equipment of field data can be encapsulated in the BACnet object model. BAS equipment is matched with BACnet device object model. A device is usually more than one data, included physical switch , amount of analog and digital signals. These data can be mapped binary object type and analog object type for BACnet through the device object model.Take variable air volume air conditioning system（VAV）for example，the corresponding relations between BAS equipment ,quantity, state and standard object types is shown in table 2.

Table2. Data object type of monitoring and control poin for BAS system

Monitoring and control poin	Standard object types	Interface position
Blower running state	BI（Binary Input）	Auxiliary points of main contactor
Blower failure state	BI（Binary Input）	Auxiliary points of thermal relay
Blower speed control	AO（Analog Out）	Inverter control point
Back to the fan switch control	BO（Binary Out）	Control circuit of main contactor
Humidifying regulating valve	AO（Analog Out）	Drive control point
Fresh air temperature	AI（Analog Input）	Temperature sensor of duct type
Return air temperature	AI（Analog Input）	Temperature sensor of duct type
Supply air temperature	AI（Analog Input）	Temperature sensor of duct type
Return air measurement	AI（Analog Input）	Temperature sensor of duct type

Data from BAS system are packaged in the way of object model , using service BACnet provides to read and write the data and to complete the purpose of data driven. Flow diagram that BACnet protocol drivers field data of BAS system is shown in figure 3.

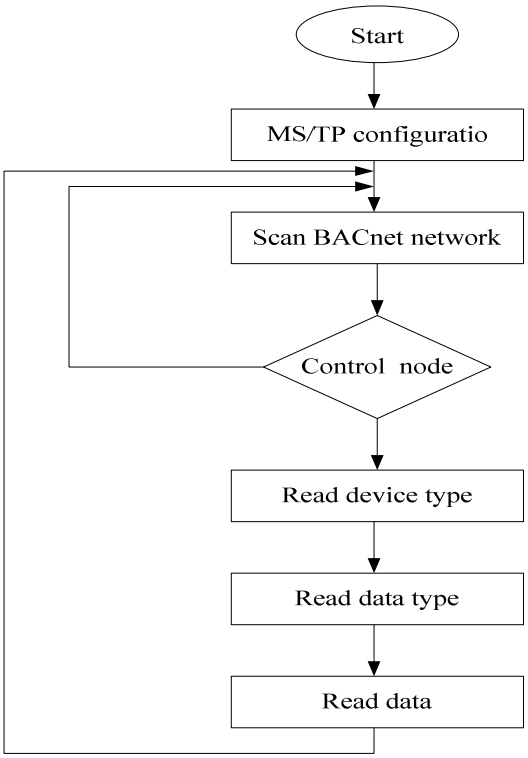

Figure3. Process of BACnet drivers field data of BAS system

3.4 Module design of conversion between BACnet data and OPC data

Through the data driven, BACnet network collects the field data of BAS system. However, this kind of data structure cannot be identificated by OPC standard. Therefore, in order to realize the system integration,a kind of structure that can simultaneously compatible BACnet protocol data with OPC standard data attributes. Data attributes of BACnet protocol include: equipment data number belonged to the device, the data type belonged to the data ,object ID of data and data that corresponds to the value. BACnet data are transformated to OPC item object that is used by OPC server through the structure. OPC Item object has three basic attributes:Value,Quality and Timestamp. Type of the Value is VARIANT that means the actual value of BAS equipment.Quality means whether the Value is valid or not. Timestamp means the time to read the data from field devices. According to the attribute characteristics of BACnet protocol data and OPC standard data,structure body is designed as the following data structure.

```
Type structTag
{int DeviceID;          //Device ID
int DataID;             //Type ID
int Object;             //Data ID
CString ItemName;   // The name of OPC item
VARIANT ItemValue;  // The value of OPC item
CString TagQuality;   // Quality of OPC item
CTime Time;  }        //Timestamp of OPC item
```

OPCItem

BACnet data tag is transformed to OPC standard data item through the above structure.Highlightly,the above structure is applied to one data,but BAS has large amounts of data,therefore, BACnet - OPC server must exist a large number of structures.Considering that the integrated system can add or remove a OPC item at any time, therefore the form of linked list is used to storage structure of data.

4.Test for BAS integration based on BACnet–OPC

Using “factorysoft” as OPC clien to test the system integration for BACnet - OPC BAS.Running picture is shown in figure 5.

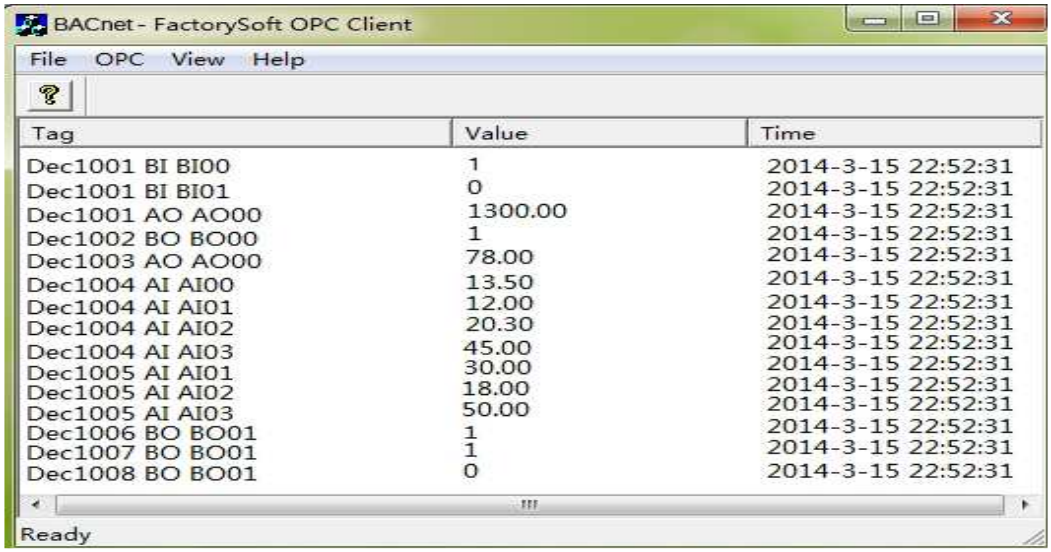

Figure.5 Running picture of system integration fou BASnet-OPC BAS

In the above picture, under the "Tag" bar “Dec1001” is on behalf of system code for one sub-system. BI means data type,and BI00 means Specific tag object. Seen from the above diagram, the OPC client can real-time monitor field data from the building automation system,and realize the communication with a third party. The requirment of system integration for BAS is achieved.

CONCLUSION

Based on the analysis of OPC standard and BACnet communication protocol,the multi-layer structure scheme for BAS integration is given in this paper.Mainly study the data structure that can transform data collected by the BACnet network into the data structure that OPC specification can recognize and use “factorysoft” to test BACnet - OPC integration system for BAS, the result shows that the system is successful.

With the improvement of modern information system integration technology and OPC standard widely used in software, development of OPC technology and the bridge between process development and platform development can effectively improve the integrated level of BAS, reducing development costs and cycles,and bringing a win-win situation among hardware, software vendors and users.

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