RESEARCH OF A NEW METHODOLOGY FOR INTEGRATING BAS WITH MULTIPLE STANDARDS

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(Received 4 February 2004; Accepted 24 July 2004)

ABSTRACT

A new methodology for integrating building automation systems (BAS) with multiple standards is proposed in the paper. The advantages of this method include interoperability of different building subsystems with different standards, a BAS workstation independent of all standards used in buildings, and integration of the BAS and the enterprise MIS. The novelty of the proposed methodology lies in the BAS workstation to be built as a uniform user interface easily and quickly. An experimental BAS workstation implementing the proposed approach has been developed; and the future work to improve the methodology is put forward. The methodology in the paper has potential application in BAS engineering.

1. INTRODUCTION

In order for a building to operate efficiently, to attract and retain occupants with its amenities and benefits, BAS integration technology – the methodology of making different building subsystems with different responsibilities work together as if a cohesive unit – has been used for many years, and it can be achieved by different means. Today, modern IT technology is widely applied in BAS integration to improve buildings’ performance. If a building is integrated with modern IT technology, all or most of its building services including HVAC subsystems, lighting subsystems, energy subsystems, fire and security subsystems, etc. have high performance, it is called a “smart building” or “intelligent building (IB)”.

The BAS integration is not a new concept, but an effective BAS integration is not just a matter of tying subsystems together, its philosophy varies and is seeing radical changes today [1]. Not too long ago, it was a feat for more than one building subsystem to be connected to relays, allowing on/off scheduling through the installation of a time clock. In the late 70s, when computers were used in building services, BAS integration took on new meaning, adding information that are shared among some subsystems to BAS. The microprocessor has become the brain of BAS and contains a wealth of information that is valuable to those who operate the physical systems. In the 80s, when fieldbus technology was introduced to BAS, automation and control networks ushered in a new era for BAS integration by bringing out standards of data communication protocol for automation and control networks, making it important and necessary for effective BAS integration to be built upon standards. This expands the BAS integration beyond just BAS to building services themselves, and brings another dimension to integration: integration of the BAS and the enterprise MIS. It is a trend that BAS needs an IT framework for facility management that offered greater access to building data and a platform to share it between a variety of building management applications [2].

Today, there are a number of fieldbus standards developed by equipment manufactures and many of them are still used in the BAS. However, it is very difficult for multiple standard networks to work together. So it is necessary to put forward a new method for integrating BAS with multiple standards.

2. REVIEW OF CURRENT INTEGRATION METHODS

The variety of standards available for integration in the BAS provide system manufactures with a firm foundation for delivering benefits and value to building owner and end users. But there are cases in the world of BAS integration where one BAS with a certain standard is hardly connected to another one with different standard for interoperability, and sometimes those that have the same standard in different ways do so. From the 80s to now, many standards such as BACnet, LonWorks and Modbus were born, most of them are still being used in BAS today and are competing to be defacto standard of BAS integration, even though BACnet was approved as an ISO standard (ISO 16484-5) in January 18, 2003 [3]. Thus, there is not one standard in use today that is employed by all system manufactures.
Even those building subsystems that use the same standard in different ways may not have interoperability. In order to get rid of this kind of embarrassment, most of standard providers developed their own tool for specifying and designing BAS integration. For example, BACnet Interoperability Building Block (BIBB) is BACnet standard’s new tool, LonMark as LonWorks’ tool. As we know, these two standards are not compatible and their BASs cannot directly connect with one another without by a gateway. As standards are evolving, it is a trend for all systems in the enterprise to involve the use of a common data infrastructure. BAS as well as voice system, video system, and business information system should reside on a common, integrated information infrastructure.

To accommodate building owners’ needs and the interest in high performance buildings, it is necessary for BAS designers to integrate different BASs with different standards together. The usual way is that, firstly BAS designers pick a single main standard that has the ability to integrate multiple standards, and then try to move forward on the assumption that all building subsystems employed in the facility can adhere to that standard. That is to say, the BAS should be chosen based on its ability to perform the primary function, and then integrated with other building subsystems using whatever standards its developers chose to build it upon. When you use this way to integrate building subsystems, it is essential to consider not only what operating standards are needed, but more importantly, how many. So the main standard is a container and is very important. However, it is the key that more attention must be dedicated to making sure that those subsystems deliver on their primary role.

Despite the success of the above integration way, there are four main disadvantages. 1) Different building subsystems can be connected with only by gateways. A gateway is a very complex and more expensive communication device. The more standards are picked, the more kinds of gateways are needed. 2) The result interfaces of BAS, including user interface, is not uniform, varying with the selection of the main standard. Even if the main standard is the same, the interfaces are also different from each other due to system manufactures’ different ways to build it upon. This in turn increases training requirements and makes an operator more difficult in response to critical information about the BAS. 3) It has no flexibility in adding in new services. When some new services want to be added to an old BAS, the BAS may be reconstructed. This case usually occurs when new services are not from the container standard. The result is that building owners have often felt trapped, locked-in to products of a single manufacturer. 4) It is hard to share data between the BAS and the enterprise MIS.

Aiming at the above disadvantages, a new methodology for BAS integration is proposed in this paper: it separates the BAS workstation from the standards used in building facilities. This method treats all standards equally and has no limitation on member of standards, so the BAS operator workstation is independent of automation and control networks, as a result, its user interface can also be standardized as uniform interface that is user-friendly. The advantages of this method include no gateway between automation and control networks, interoperability of automation and control networks, and integration of the BAS and the enterprise MIS.

3. NEW BAS INTEGRATION METHOD

Although there are a lot of methods for integrating BAS and achieving interoperability of subsystems [4], we propose a new method from another point of view. As long as all subsystems implement some interfaces defined in this new method, it doesn’t matter which standards those subsystems employ. All subsystems are all equal service providers in the eyes of a BAS manufacture.

Analogous to computer operating system Linux [5], in which a number of possible hardware devices that are supported and a number of network standards that can be used are abstracted by its network kernel subsystem so that user processes and other kernel subsystems can access the network without necessarily knowing what physical devices or protocol is being used, the new BAS integration method abstracts all kinds of underlying automation and control networks and their standards to some independence interfaces, upon which the BAS workstation is built.

Fig. 1 shows the philosophy of the new BAS integration. It is composed of a database entity, four interfaces and three modules. In this method, enterprise MIS, which is optional, can be integrated with BAS by database interface, which may be a simple set of public access operations of database including add, delete, read and update.
Database stores static structure and dynamic operation information of all building subsystems, and it is a map of the architecture of automation and control networks and the relationship of the data moving between them. Database Interface separates Operator Workstation from underlying module, and is implemented in these two modules respectively. This makes BAS integration independent of automation and control networks employed in buildings.

Operator Workstation is a “window” of Database, which visualizes the data that is being operated and monitored by operator. All data displayed by this module comes from the database entity directly, not from underlying modules. Operator Workstation Independence Interface defines the framework of BAS operator workstation. It is composed of a full set of operations or functions, all of which must be implemented in full-fledged operator workstations. Users can interact with all buildings in the same way through this interface regardless of the brand of controls actually installed in the facility.

Automation and Control Network Standards (Protocols) are responsible for implementing each of the possible automation and control network protocols, such as BACnet protocol, Modbus protocol. Standard (Protocol) Independent Interface provides an interface that is independent of automation and control network protocols. Any module that implements this interface can be added in. So, in theory, this new integration method can integrate all automation and control standards.

Automation and Control Network Device Drivers communicate with hardware devices - the network interface cards (NIC). There is one device driver module for each possible NIC. Usually this module only implements the physical and MAC layer of a protocol. Device Independent Interface provides a consistent view of all of NICs so that higher modules do not need specific knowledge of the hardware in use.

As a note, this new BAS integration method can be deployed locally or distributively. If a BAS has a database server alone, the operator workstation may be a simple “network browser”.

Fig. 1: Conceptual structure of new integration method
4. EXPERIMENTAL EXAMPLE

We construct a simple experimental BAS system shown as Fig. 2. This BAS system employs a BACnet standard and a proprietary standard. The BACnet standard is an internationally recognized communication protocol standard specifically designed for integrating building automation and control systems. The proprietary standard is a simple experimental protocol that is encapsulated in UDP protocol. Its purpose is only to start/stop building equipments.

To describe the status and parameters of building equipments, we make use of the concept “object” that is defined in the BACnet standard to construct the BAS database. In this example, the BAS database is a SQL Database. Fig. 3 shows its E-R model, it depicts the architecture of the experimental networks and the relationship of the data moving between them in a conceptual view of database.

Fig. 4 is the Graphical User Interface (GUI) of the BAS operator workstation. The GUI is intuitive so that an operator is easy to learn and use it correctly. Although it is not a full-fledged commercial BAS operator workstation, this experimental GUI is a completely interactive user interface and offers the following features:

- Tree navigation
- Parameter change of building equipment
- Setpoint adjustments
- Configuration of operators
- Trending
- Scheduling
- Alarm/Event information

![Fig. 2: The architecture of experimental BAS system](image1)

![Fig. 3: The E-R diagram](image2)
5. CONCLUSION AND FUTURE WORK

A new methodology for integrating BAS with multiple standards is proposed in the paper. An experimental example without a gateway testifies that this method is effective and applicable in BAS engineering. This method provides a platform and flexibility that will allow BAS integration to extend its scale and share building data with enterprise MIS. The advantages of this method include:

- No a gateway that connects automation and control networks
- Independence of the underlying automation and control networks
- Standard GUI for the BAS operator workstation
- Integration with enterprise MIS

On the next step, there are the following things to be done to improve this new methodology so that all BAS integrations are simple and routine procedures.

i. To define and standardize the framework of the BAS operator workstation
ii. To define and standardize the structure of the BAS database
iii. To define and standardize the four independence interfaces

ACKNOWLEDGMENT

The authors would like to express their sincere appreciation to all contributors of VTS, because the authors made use of some functions of VTS-2.4.0-source.zip to build the Automation and Control Network Standards module.

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