지능형 빌딩 시스템을 위한 임베디드 웹 서버와 XML 웹 서비스의 구현

Implementation of Embedded Web Server and XML Web Services for Intelligent Building System

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Abstract : The existing building control and automation systems which have been applied to buildings are provided by many different vendors and each vendor has its own proprietary protocol. There are many problems in system integration since those building control and automation systems belong to each vendor. Also, the problems of cost and space increase, due to the usage of personal computers as the control servers of DDC(Direct Digital Control) in each facility. Those problems mentioned above can be effectively resolved by using XML Web Services and Embedded Web Server. Embedded Web Server and XML Web Services are technologies emerging out of the IT industries and there are many researches to apply them into many fields. In this paper, Embedded Web Server and XML Web Services are proposed to be used in building control and automation system to resolve problems in building system integration.

Keywords : intelligent building system, XML web service, embedded web server, system integration

I. Introduction

There have been developed a lot of building control and automation systems as building systems become more intelligent. A building system consists of many facilities such as HVAC (Heating, Ventilating, and Air Conditioning) system, light system, power system, parking control system, and security system, etc. Therefore, a building system naturally needs more control systems for their facilities [1,2].

A building system is generally composed of facility servers to control and manage DDCs(Direct Digital Control) of each facility and an SI(System Integration) server to unite those facility servers for providing integrated services.

In the building system integration, it is important to have interoperability for the convenience of the building management/maintenance and the reduction of energy consumption. However, each facility usually has disparate data format and communication method and it has made the perfect building system integration difficult to be realized [3,4]. Because the existing facilities and the upgraded facilities might have disparate data formats. Moreover, the same type of facilities may have different data formats by vendors, which causes a problem in data sharing even though they have the same protocols.

Applying XML Web Services which is emerging out of IT fields to building systems could resolve the problem. However, the data represented by XML has approximately 3 times larger in size than that represented in the existing system. Moreover, it can be also a problem that the realization of XML on a device level is in need of the processor unit of higher performance with larger memory [5].

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II. Intelligent Building System

1. Intelligent building

The concept of intelligent buildings (or smart buildings) was introduced at the end of the 1980's. An intelligent building usually means a building with a "large" amount of advanced functions and/or a high degree of automation. However, it is difficult to tell how many and what kind of advanced functions are needed in a building in order to be called intelligent. The following is the definition given by European Intelligent Building Group (EIBG) (Arkin and Paciuk 1997) [1,6]:

An intelligent building creates an environment that allows organizations to achieve their business objectives and maximizes the effectiveness of its occupants while at the same time allowing efficient management of resources with minimum life-time cost.

2. Building system integration at present

Since the building control and automation systems which have been applied to building systems so far have different protocols by vendors, they are subordinated by the different vendors and have problems in the system integration. To overcome the problem, open standardized protocols such as BACnet, LonWorks and Modbus have been introduced and are being used together for building facilities.

The building system integration for currently being

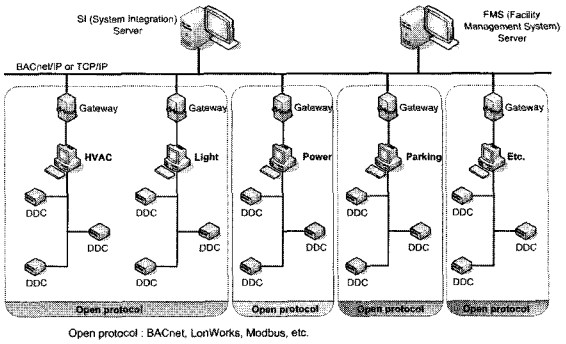

그림 1. 현재의 빌딩 시스템 통합.

Fig. 1. Current building system integration.

constructed buildings is shown in Fig. 1. Open protocols are used for each system so that it is guaranteed the interoperability. Therefore, it is possible to provide various integrated services and reduce the costs in building maintenance, management and energy consumption. On the other hand, it still has different data formats and communication methods by different facilities so that the perfect integration cannot be provided [7,9].

III. Proposed Building System Integration

The proposed building system integration is illustrated in Fig. 2.

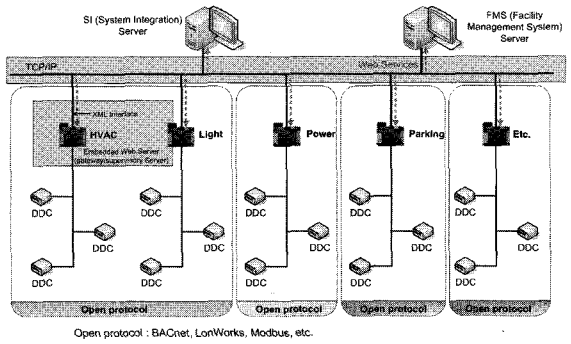

그림 2. 제안한 빌딩 시스템 통합.

Fig. 2. Proposed building system integration.

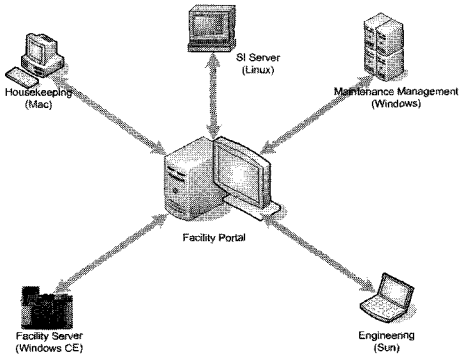

그림 3. 웹 서비스를 이용한 설비 포털.

Fig. 3. Facility portal using web services.

To resolve the problems of building system integration mentioned in previous chapters, a method of using Embedded Web Server replacing PC servers and XML Web Services(with TCP/IP) enabling communications between facility servers and SI server is proposed in this paper.

IV. Implementation and Test

In this paper, I have built a small intelligent building system showing the possibility of PC server as an alternative to the embedded server. I have also set up XML Web Service to confirm the smooth communication with other different systems.

In this test, the Embedded Web Server controlled 3 lights, 1 fan, 1 valve, and 1 temperature sensor and transmitted the temperature information to the FMS(Facility Management System) server.

1. Embedded web server

1.1 Implementation of embedded web server

Embedded Web Servers are micro controllers that contain internet software and operation codes that monitor and control the system. In order to obtain the Embedded Web Servers functions, the followings are needed. First, because the embedded system has a small memory, it needs a divided memory block structure that can manage the memory with more efficiency. Second, a dynamic page must be created in order to send the information, with the use of Ethernet TCP/IP protocol, RS-232, RS-485, Wireless Network, Bluetooth, from the subsystem(Embedded device and DDC) to the web browser. Therefore the information on the web browser matches the information on the actual subsystem.

In Table 1, differences between servers used in previous control system and embedded system are described.

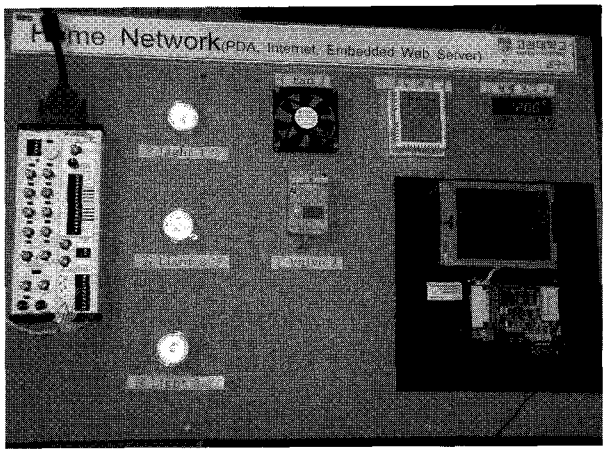

그림 4. 임베디드 웹 서버와 XML 웹 서버를 이용한 지능형 빌딩 시스템 제어 테스트.

Fig. 4. Intelligent building system(home network) control test using embedded web server and XML web server.

표 1. 기존의 서버와 임베디드 웹 서버의 비교.

Table 1. Comparison with existing server and embedded web server.

	Existing system	Embedded system
OS	Windows XP	Windows CE .NET
CPU	CISC Processor	RISC Processor
HW	General diffusion style	Manufacture according to function
Application	Save to auxiliary memory	Embedded in ROM & RAM

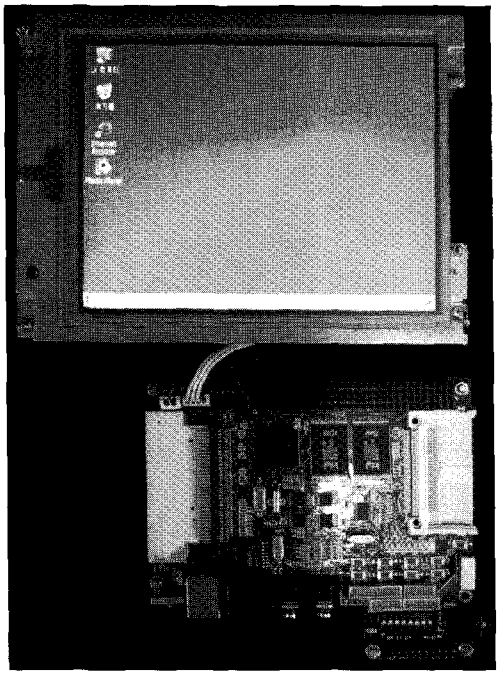

그림 5. 임베디드 웹 서버의 구현.

Fig. 5. Implementation of embedded web server.

Especially, in the interface among embedded system's characteristics, beside Ethernet, RS-232, we can find the extension usable advantage of Bluetooth, USB, PCMCIA, CF, and MMC.

1.2 Test of embedded web server

A web server serves web pages to clients across the internet or an intranet. The web server hosts the pages, scripts, programs, and multimedia files and serves them using HTTP, a protocol designed to send files to web browsers and other protocols.

The operation of web server can be checked by inputting IP address and a Ping Test. A case of inputting a real IP address(http://163.152.17.134) is shown in Fig. 6. The message "The Windows CE Web Server is enabled on the device" indicates that the server is properly operated. It is the initial state when a web server is firstly built and is possible changed by another user-designed html file.

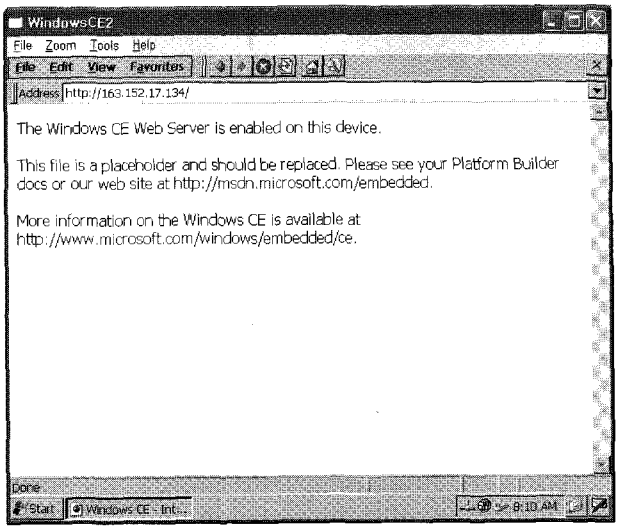

그림 6. 웹 서버 테스트.

Fig. 6. Test of web server.

2. XML web services

2.1 Implementation of XML web services

XML(eXtensible Markup Language) is a text file arranged in a specific format, which is easily transported among computer systems and across operating systems. For example, an XML file created on an Apple Macintosh can be sent to a computer running Microsoft Windows or Linux, or to a mainframe, or Unix server or embedded computing platform such as a BAS(Building Automation Systems) controller.

Web Services are created using a set of industry standard protocols, which include SOAP, HTTP, WSDL and XML that make it easy for systems to communicate without prior knowledge of each other.

Stand-alone, monolithic applications are difficult to customize or extend. The use of COM(Component Object Model)/DCOM(Distributed Component Object Model) and other distributed object technologies made customization and extension of applications simpler but also carries its own problems. Configuring DCOM to run across firewalls, for example, can be an interesting exercise. Embedded systems are becoming smarter and are increasingly shipping with network connectivity. This being the case, it would be extremely useful to have the ability to remotely configure or monitor an embedded device, have an embedded system integrate with other systems on a local network, or have the global networking infrastructure known as the Internet. Web Services use HTTP for communication, the lowest common denominator of communication technologies for Internet-based devices.

In order to support XML Web Services, a Windows CE .NET project must contain the following components: HTTPD server, COM, SOAP Server, and optionally Active

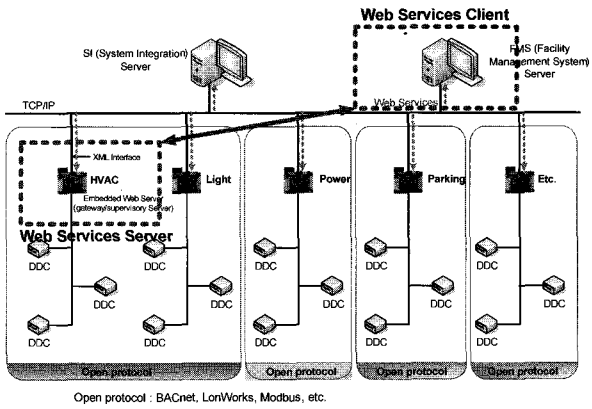

그림 7. XML 웹 서비스의 구현.

Fig. 7. Implementation of XML web services.

Template Library(ATL).

Windows CE .NET includes SOAP Toolkit version 2.2 functionality, which is directly equivalent to the functionality in the Windows Desktop SOAP Toolkit 2.2. The compatibility between the desktop SOAP toolkit and Windows CE .NET support for SOAP makes it possible to develop and test SOAP servers on the desktop, and then port the code with minimal changes to Windows CE .NET.

The SOAP server is simply a COM object, perhaps created by using the ATL COM AppWizard within eMbedded Visual C++ 4.0. There is some additional information needed to correctly invoke the functions exposed by the COM object and to return an appropriate XML packet to the client application, which is handled by the Windows CE .NET SOAP Server [10].

For the experiments, a Web Service is constructed between an HVAC facility server and an FMS (Facility Management System) server, where the HVAC server is Web Services server and the FMS server is operated as Web Services client.

2.2 Test of XML web services

The test of the constructed Web Services is conducted with the communication tests between the Web Services server(Facility server) and the Web Services client(FMS server). The Web Services is tested with a desktop application written in C# on Visual Studio .NET platform.

The Web Services client application program is written by referring a WSDL file (http://163.152.17.134/mywebservice.wsdl) in the Web Services server. That is to say, the functions of the sever application, GetInt(), GetString() are referred in writing the client application program.

The communication test program consists of a part presenting the IP address of the server and another part for a push-button calling the Web Services.

Here is how the C# application looks when running. The button has already been clicked. The return values from the XML Web Service are being shown in the two edit controls. It can be checked that the test program properly works when the button clicked from Fig. 8.

표 2. 테스트 환경.

Table2. Test environment.

	Web Services Server	Web Services Client
Server	Facility server	FMS server
OS	Windows CE .NET	Windows XP
Processor	Intel PXA255 400Mz	Pentium 4 2.8GHz
Memory	SDRAM 64M, Flash 32M	DDR SDRAM 1G
I/O port	USB, PCMCIA, IrDA, CF, MMC	USB
Ethernet	10BaseT	100BaseT
Wireless LAN	IEEE 802.11b	X

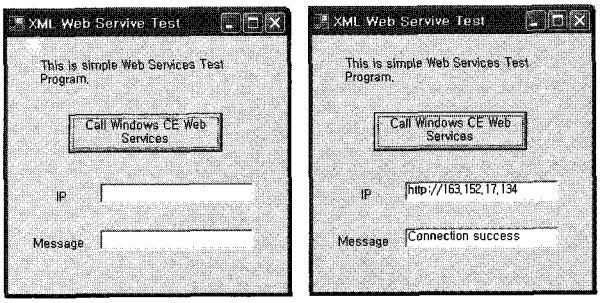

그림 8. Client에서의 웹 서비스 테스트 프로그램.

Fig. 8. Web services test program on client.

V. Related Works and Future Works

1. Related works

There have been numerous building control systems developed as buildings have become more intelligent. Building control systems have disparate data formats and protocols by vendors and it makes the integration of a building system difficult. There have been researches on standardizing open protocol considering the problem. At present, there are many open protocols such as BACnet, LonWorks and Modbus, etc. They are characterized to control many types of facilities and being used together in a building system. Nevertheless, they still have different data formats and communication systems which make the perfect system integration hard to be realized.

To resolve this problem, there are researches being conducted on applying XML Web Services into a building system. XML Web Services are technologies currently being emerging out of the IT industries. In this way, the building

control and automation systems are developed in a way to be more intelligent and to be combined with the existing IT infrastructures. This enables a building system to be controlled and monitored through internet [5,11].

There are also researches on open and distributed system for building systems using open protocols and XML Web Services [3,12].

2. Future works

In this paper, PCs for facility servers are replaced with Embedded Web Servers and XML Web Services are applied to building system. Embedded Web Server for intelligent building system requires the functions of expand port, middleware, XML Parser and Web Services server/client. An XML Parser for transforming data format of facility server and a Web Service server/client for communication between building systems written in different languages on different platforms are built. Expand ports of RS-232 and RS-485, etc. and a middleware should be developed for DDC control and transforming disparate protocols, respectively. In addition, it is also needed to compare the performance of Embedded Web Server with the one of PC server and researches on security of embedded system are required as future works.

VI. Conclusions

The building control and automation systems which have been applied to intelligent building systems belong to a variety of vendors and those vendors have disparate protocols, which causes problems in the building system integration. In addition, using PCs as servers for DDC management and control of each facility brings about the increase of costs and installation spaces. Each facility server controls DDCs and has the simple function of transmitting DDCs data to FMS server. Currently a general PC is taking care of this function but this can be replaced with an embedded web server to reduce the cost and the installation space in accomplishing the same function.

This paper proposes a method of using XML Web Services and Embedded Web Server as a resolution of the problem. Using XML enables users to freely manipulate the structuralized database so that it is possible to transform facility data format and share them. By using Web Services, communications between applications written in different languages on different platforms are feasible. Embedded Web Servers can be implemented effectively in terms of both cost and energy consumption. They also can be optimized for certain tasks. Therefore it can reduce cost and installation space.

Those technologies of XML Web Services and Embedded Web Server are already being issued in IT industry. To resolve the problems in existing building systems, XML Web Services and Embedded Web Server are proposed for control and automation of intelligent building system. The proposed system is realized, applied to a real building system, and test its performance.

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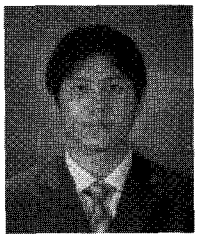

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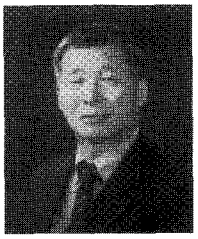

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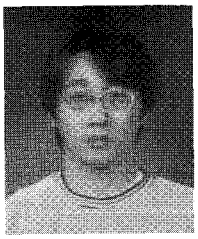

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