Some Aspects about Smart Building Management Systems - Solutions for Green, Secure and Smart Buildings

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Abstract: - In this paper we present some aspects related with the impact of the new digital, communication and facilities technology development in the implementation of Smart Building Management Systems (SBMS) – integrated tools for monitoring, controlling and ensuring the control, comfort and efficiency in use of Intelligent Buildings integrated in Intelligent Campus. The integration becomes possible due to the applications of advanced IT technologies such as Web Services. The Smart Building Management Systems can be integrated and managed at enterprise level or even at campus level [10]. So, taking into account the advantage of integration, we estimate that we will assist to the replacement of individual BMS as key elements for green buildings with SMBS, that integrates functions of multiple BMS through a single platform system that can be implemented in a private cloud.

Key-Words: - Building Management Systems, green building, smart building management systems, smart cities

1 Introduction

A city is a collection of individuals who live and work together. It is important to point out their cohabitation goal, which is to obtain results greater than the sum of their individual actions. It is defined by a dynamic work in progress, with progress as main objective.

In fact, a city is an interconnected system of systems, which is made and defined by infrastructure, operations and people. “A tripod that relies on strong support for and among each of its pillars, to become a smarter city for all” (IBM - http://www.ibm.com/smarterplanet/us/en/smarter_cities/overview/index.html).

Cities generally have advanced systems for waste management, utilities, transportation, health, security etc. The great IT companies have already promoted the concept of Smart City.

In [Fig. 1] the smart city is defined by the following important elements: intelligent Energy, intelligent safety, intelligent buildings, smart water, intelligent transport, smart healthcare. It can balance its social needs, environmental needs, and commercial needs - by optimizing resources at its disposal.

On the other hand, in order to provide the facilities necessary for maintaining a comfortable, secure and efficient energy consuming working environment, the buildings must be provided with some form of mechanical and electrical services. These services must be controlled by some means to ensure that their functions are conforming the necessities.

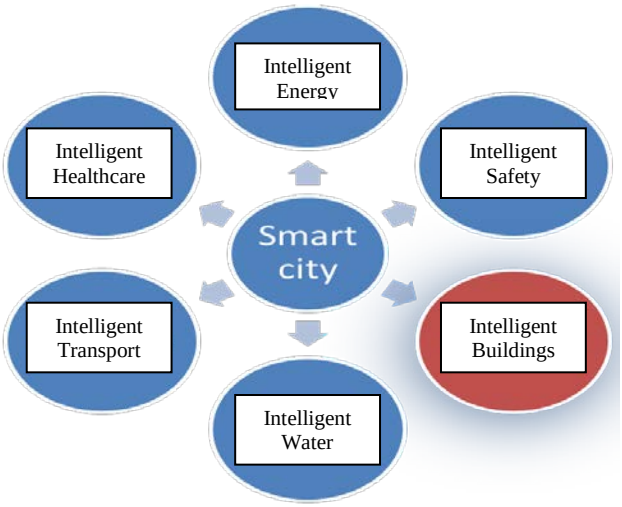

Fig. 1. The smart city concept

In the frame of the smart city concept, a Smart Building is the place - house, office, holiday house - that use modern technology for its automation systems and equipment in order to ensure the security, comfort, efficient energy consuming and even efficient task scheduling for the building activities. It is important to point out that these Smart Buildings must also provide the needed

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functions imposed by the Smart City. All these functions will be integrated at the city level in order to permit the realization of the Smart City.

2. Intelligent building pyramid

The basic controls of a building can be realized in the form of manual switching, time clocks or even temperature switches that provide the on and off signals for enabling pumps, fans or valves etc.

In [10] is given a proper representation for the Intelligent building pyramid, which express very well the evolution of intelligent building systems (Fig. 2).

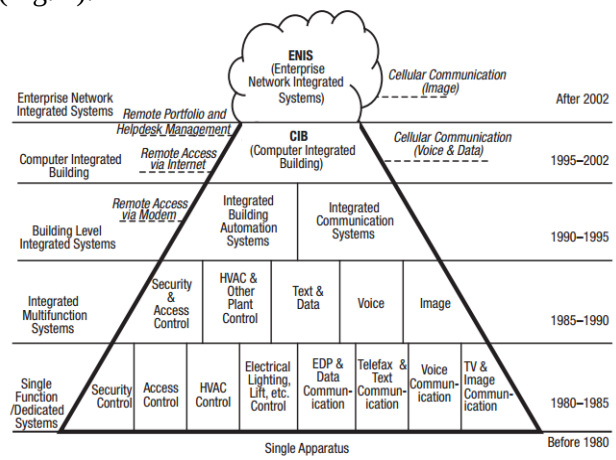

Fig. 2 Intelligent building pyramid [10]

With the rapid evolution of technology, smart building management systems are becoming more and more advanced, and the level of integration is being developed progressively from the subsystem level to total building integration and convergence of information systems [10]. At the beginning the automation of building systems were achieved at the level of individual equipment, but after 1980 these equipment began to be integrated. So, at the stage of building level integrated systems, the automations elements and the communication systems were integrated at building level as building automation system (BAS) and integrated communication system (ICS). The system could be accessed remotely via telephone network using a modem, while the cellular phone for voice and data communication was introduced to the market [10].

At and after the stage of computer integrated building, due to the intensive use of Internet Protocol and to the increase of communications capacities, convergence networks became available and were used in practice progressively. The integration was at the building level, with remote monitoring and control achieved via the Internet. At the last stage the smart building management systems can be integrated and managed at enterprise level or even city level [10].

SBMS of one building are merged with SBMS of other buildings as well as other information systems via the global Internet infrastructure (these systems are not enclosed within buildings); Integration and management at this level become possible due to the applications of advanced IT technologies such as Web Services, XML, remote portfolio management and helpdesk management. It is important to point out that a great impact in all our lives have the high development of communications, that permitted the image communication via cellular phone to be brought into practical use [10]

3. SBMS – the new trend in designing smart buildings BMS

The purpose of a Building Management System (BMS) is to automate and take control of all facilities operations in the most optimal and efficient way, within the constraints of the installed devices. A Building Management System (BMS) is a computer-based control system installed in buildings that controls and monitors the building's mechanical and electrical equipment such ventilation, lighting, power systems, fire systems, media systems, communication systems and security systems. A BMS consists of software and hardware; the software program, is usually configured in a hierarchical manner, and can be proprietary using protocols as C-bus, EIB/KNX, Profibus (PROcess Fieldbus), EIBnet/IP etc. As the interest for BMS was increasing, vendors are producing BMSs that integrate using Internet protocols and open standards like DeviceNet, SOAP, XML, BACnet, Lon and Modbus [1] [2] [4]..

BMS systems are delivered as fully integrated systems and services through companies like Siemens, Honeywell, Johnson Controls, Rockwell Automation, Delta, TAC and others. There were also developed some more flexible solutions that link BMS systems to enterprise management software like SAP, OpenView, Archibus, Maximo, Augusta Systems, GridLogix, Network Harbor, North Building Technologies Ltd, and Tridium [5] [6][7].

The level of control via the BMS is dependent upon the information received from its sensors and the way in which its programmes tell it to respond to that information. As well as offering a precise degree of control to its environment, it can be made to alarm on conditions that can't meet specification or warn of individual items of plant failure [9].

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BMS is basically a solution which is integrated into a facility to ensure an environment that is safe, secure, comfortable and energy efficient [11]. In order to be efficient, the BMS must be properly integrated into the facilities,

Typical applications of BMS in a building are given in Fig.3. Taking into consideration that BMS can be used for minimizing energy consumption and maximizing indoor comfort, it results to be an important tool for any sustainable design. A fully optimized BMS can save energy cost to the extend of 15-20% as compared to a building without BMS [11].

A green building can have the best of systems, lighting, efficient glass etc; however, optimization of performance can be ensured only through regular monitoring with the help of BMS. BMS can help real-time monitoring and record of past data. This enable diagnosis in the event of any non-performance [5].

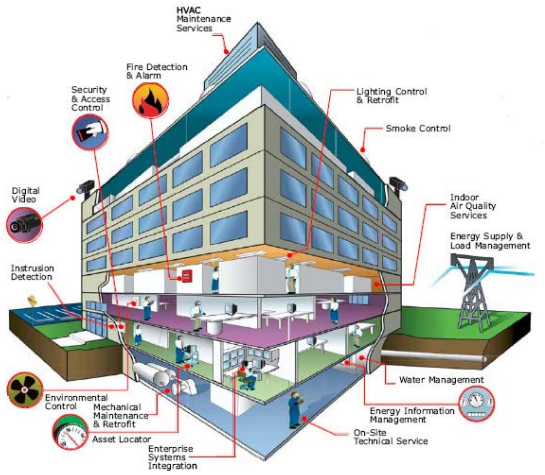

Fig. 3 Typical application for BMS, SBMS

SBMS, having like BMS the role of ensuring an integration platform, they are different from a conventional BMS system, because it brings together three key technology frameworks [8]:

- Enterprise Application Integration
- Business Process Management
- Service Portal

The Internet is fast becoming the default enterprise network, driving business transformation in every area of activity. Wireless & broadband technologies are leading to the development of mobile technologies, that change consumer expectations and use dramatically. The Systems for managing the buildings, are evolving from an integration platform sitting inside the building to a service platform sitting in Internet, and the SBMS functionality become delivered as service. The Internet enables the development of mobile cloud technologies with high implications in the development of SBMS, enabling the delivery of new types of services that exploit the ability to aggregate, consolidate and streamline processes, services and systems across multiple buildings, people and geographic locations. Also, real-time information from any site can be captured in real time and turned into actionable business intelligence [14].

SBMS provide a foundation for new forms of services. SBMS eliminate the requirement for the multitude of expensive BMS, improve functionality and overall performance of systems by integrating them into an enhanced IT infrastructure. Furthermore, the implementation of client defined Business Process Management across the entire integrated Electromechanical and IT Infrastructure is giving an important satisfaction to the costumer. Buildings today are provided with multiple proprietary networks for various BMS, and telephony and data networks. It leads to complex and expensive network management issues, high installation costs with limited functionality and automation. Thus, a Managed Services Platform that provide a Single Management System with integrated, intelligent functionality is the solution for a SBMS [8].

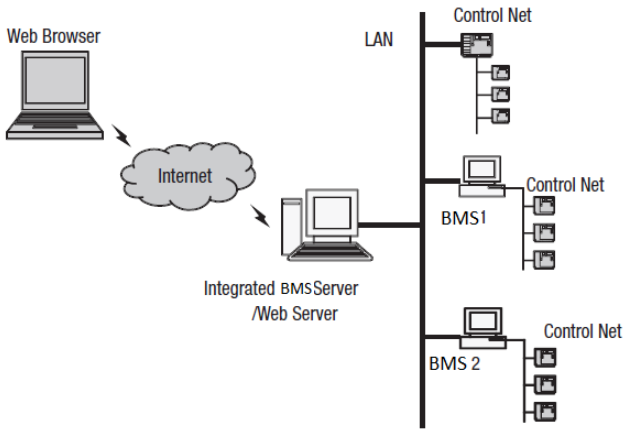

Fig. 4 BMS integration on the Internet – LAN-integrated Internetaccessible [10]

The use of Internet technologies for developing the management software for SBMS has the following advantages [10]:

• It allows developing quickly the software at a low cost (many standard functions and tools can be used and adopted directly).

• the developed software packages for management are more open in terms of protocol and

technologies. So, it becomes easier for ordinary users to use them

• software packages can easily adopt the management functions of new 'third- party' devices and systems - many of the hardware devices are developed to be Internet compatible.

When is considered the integration of SBMS with the Internet at management level, current applications can be illustrated by two typical categories - which are different in terms of the degree of integration [10].

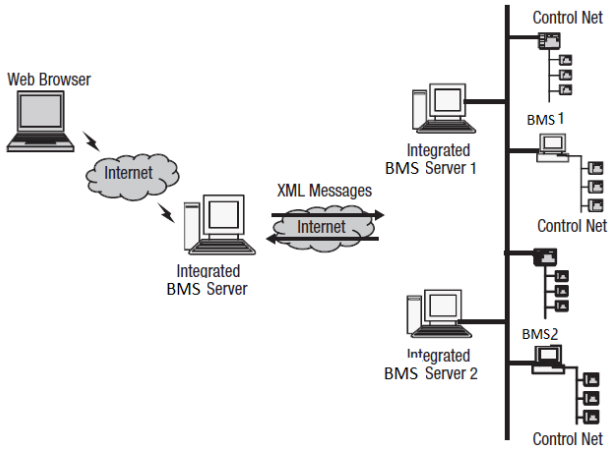

Fig. 5 BMS integration on the Internet – information and services integration using middleware technology [10]

situation represented in Fig. 5, a kind of data and services integration on the Internet, is the real "information and services integration" on the Internet. In this case, different BMSs communicate over the Internet using middleware technology, with BMSs and

Devices exchanging data and information. The middleware components communicate by standard protocol, such as Extensible Markup Language (XML)

protocol, providing a series of Web Services to be accessible by customer's applications. The applications can request data and control data points of various BMSs by the Web Services method. It is important to point out that BMS software may also invoke other Web Services on the Internet to achieve specific functions (a weather bureau could offer a Web Service that allows a BMS to automatically retrieve temperature forecast data). On the other hand, the BMS itself could offer a Web Service [10].

In our days, due to the development of communications capacities, all networks are beginning to converge and the total integration of BMS into the SBMS it is now a reality. New technologies now make it not just possible but convenient to route voice and video phone calls over an enterprise's data network, as well as over the Internet. Voice can be transferred by VoIP technology on the Internet or intranet.. The video systems (CCTV) and audio system can also be integrated into the IP networks of BMS and therefore merged easily into the enterprise network. The enterprise network usually performs as the data network for office automation systems, and provides e- mail and Internet access, telephone network (VoIP), videoconferencing network, video on demand network and digital TV network on the same network. In such a way the total integration of building management systems can be carried out and the total integration of SBMS (i.e. building automation, communication automation and office automation) is achieved easily on the basis of IP technologies and an enterprise network [10].

3. Existing Platform Solutions for Implementing SBMS

In [13], Ariel Schwartz says that "the prototypical smart building project comes from IBM, which is turning its 280,000 square foot headquarters in Armonk, New York into a pilot for the company's Smart Building initiative. Features of the system include a building management system that keeps track of 7,600 points of data about system performance (i.e. hot water, HVAC, security), automatically generated energy and operational alerts, and security badge scans that keep track of how many people are in a building at any given time (to optimize lighting and heating). Companies like IBM and Johnson Controls that focus on smart building projects can expect a windfall in the coming years as building managers realize that these high-tech, ultra-complex systems actually pay off".

The ability to collect, analyze and sort building data quickly is critical to the real-time energy and performance optimization of a smarter building.

IBM, was one of the first important Companies interested in developing solutions for smart cities and also for SBMS. So, IBM implemented the IBM TRIRIGA Energy Optimization solution.

IBM TRIRIGA Energy Optimization provides [12]:

- Real-time data gathering and analysis of energy and operational metrics of all infrastructure assets.
- A consolidated, role-based dashboard view of building data. It can be visualized energy,

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environmental and portfolio performance metrics.

- Integrated energy and facilities operations to help increase building management effectiveness, staff productivity and energy efficiency.
- Support for multiple building management systems to provide a comprehensive, integrated building management solution [12].

Another solution offered by IBM is IBM TRIRIGA: Facilities Management. It provides a single, integrated workplace management system to manage the life cycle of facilities. It delivers business analytics, critical alerts and automated processes to increase visibility, control and automation of real estate management, capital projects, space management, facility maintenance and energy management [12].

The third solution for SBMS offered by IBM is IBM Maximo: Enterprise Asset Management [12].

Actionable Business Architecture for Smarter Cities, an IBM product, consists of a set of operating models, including a model for the city ecosystem (city ecosystem model), models for individual systems of cities and models for shared functions like finance, HR, and payroll. All these models, can be further examined using performance metrics, process models, IT models, business solutions and project initiatives. This is a solution for aligning business elements with the city's priorities and for reducing their complexity to a manageable level [13].

There are also other propprietary solutions on the market. The iViva.works EAI Framework (Fig. 6) is quite different from the integration capabilities of other commercially available BMS systems [8]:

- iViva.works EAI works across virtually any system or application including control systems, enterprise business applications and transaction based systems
- iViva.works EAI Framework is object-oriented. The Framework provides the ability to create an integrated application structure/middleware of hierarchical components (Application Objects) using object-oriented workflow methodology

Distinctive features of the iViva.works EAI Framework include [8]:

- Global application changes can be propagated from Application Object templates
- It is possible to configure objects centrally while run time processing can be distributed
- An Application-Level Security Gateway enables the isolation of subsystems and applications within a private network, behind a router and firewall so that no public IP address is exposed.
- Application Objects can be configured to build relationships between disparate applications and subsystems enabling condition-based/event-based management of processes iViva.works BPM Framework includes tools and functions for management providing business visibility in operations and maintenance: Event Recognition, Process Initiation, Process Tracking, System Association, Exception Reporting, Process Modelling, Generating Statistics [8].

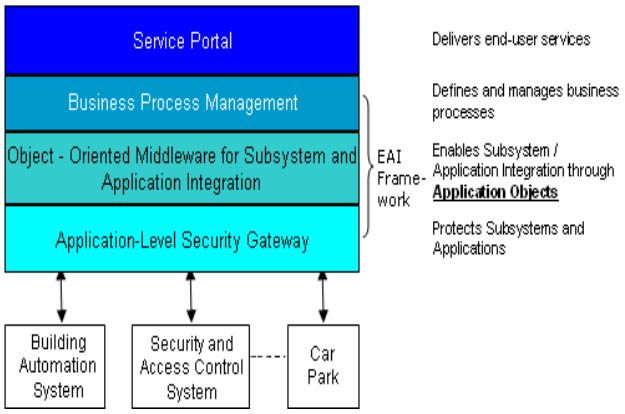

Fig. 6 iViva.works EAI Framework [8]

4 Our Proposed Platform Solutions SBMS

In present we have already implemented at University of Oradea a BMS for a laboratory for teaching Intelligent building facilities to our students enrolled in a Master Program named: Engineering Building Management Field. It was developed in the frame of an HU RO Project, together with University of Debrecen. We intend to develop at University of Oradea a SBMS, for managing the building facilities of our Campus A. Our solution is based on a private Cloud implemented with Eucalyptus Framework [15] [16]. We already have implemented such a Cloud at the Computer System Architecture Laboratory, and we intend to use it in order to realize an integrated building management solution for the entire Campus.

Eucalyptus is easy to install and flexible for integrating. The software is very modular, combining various Web services that inter-operate using standard communication protocols. It implements machines and virtualized storage resources which are interconnected via a network level 2 OSI (Open System Interconnect).

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From the perspective of an applications running at client level, the application programming interface is compatible with AWS interface, with support for both SOAP and REST. Other interfaces can be also integrated by customization.
Each high-level component is implemented as an independent web service that exposes a programming interface as a WSDL document that contains the operations that the web service can perform and the structures of the input and output data. It permits also to integrate existing Web service features (such as policies for secure communication between components).

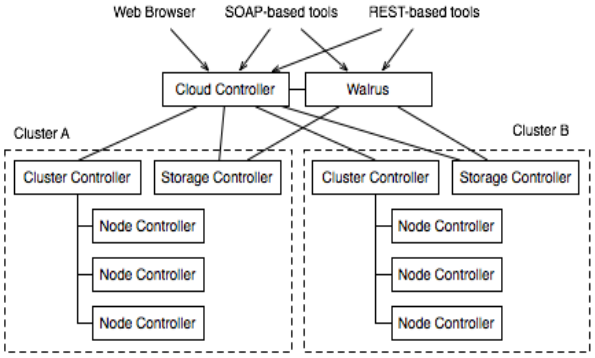

Fig. 7 Eucalyptus Architecture [17]

According with [17], the Eucalyptus architecture includes five components (Fig. 7): Cloud Controller (CLC), Walrus, Cluster Controller (CC), Storage Controller (SC) and Node Controller (NC).
The private cloud was deployed using the binary packages of Eucalyptus 2.0.3 open source for CentOS operating system, as presented in [15].
At present, we use the KNX protocol, an OSI-based network communications
protocol for intelligent buildings. KNX is designed to be independent of any particular hardware platform. A KNX Device Network can be controlled by anything from an 8-bit microcontroller to a PC, according to the needs of a particular implementation. The most common form of installation is over twisted pair medium.
KNX is approved as an open standard to: International standard (ISO/IEC 14543-3), Canadian standard (CSA-ISO/IEC 14543-3), European Standard (CENELEC EN 50090 and CEN EN 13321-1), China Guo Biao (GB/Z 20965).
We have to ensure the security facilities for 8 buildings, which includes, the detection systems, the CATV monitoring systems, and the fire detection systems. We intend also to develop an energy monitoring system, that will monitor the energy consumed for these buildings and will balance the energy source from geothermal, to solar and electrical. We already have a geothermal plant at our university, and some projects that are ongoing for renewable energy sources.

4 Conclusion

The goal of our research was to identify the new trends for managing smart buildings in order to identify a potential solution for implementing SBMS in our university. The efficiency of using SBMS instead of using individual Building Management Systems (BMS) at a campus level is obvious.
In conclusion, as the integration is essential for most functions of intelligent building systems (such as automatic monitoring and management, and building performance optimization and diagnosis), the integration of Intelligent Building components and subsystems has been the trend of the new technology development. The integration of the automation and control systems is the basis for function integration, which increases the flexibility and possibilities of intelligent management of buildings.
Systems that consist of traditional technologies have many constraints in terms of information exchange and integration. So, the development of digital and communication technologies have a very important role in the integration process. The cloud computing, and even the mobile cloud computing providing high power in computation, communication and in information processing, is the key element of the new SBMS generation.
Distributed intelligence is a major philosophical solution to ensure the reliability of complex SMBS.

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