ADOPTING IOT APPLICATION PLATFORM TO CONSTRUCT SMART BUILDINGS FOR SMART CITIES

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ABSTRACT

Internet of things (IoT) application platform provides effective connections between nodes and cloud. Smart building with IoT (SBIoT) technology provides urban designing and planning with economic insights into creating a data-driven environment. In this paper, initiatives regarding smart building research are reviewed and presented in order to illustrate this complex concept of SBIoT. In the second part, we review one smart building case, a famous mobile phone brands headquarter (H-building) in Taiwan. It was an office building transforming from conventional green building toward SBIoT. Through an in-depth case study, we propose a model of integrated IoT architecture that can be used to develop smart building solution.

Keywords: Smart city, smart building solution, IoT application platform, integrated IoT architecture.

INTRODUCTION

Smart city is a wide discussed issue recently while city assets management can be easily reached by integrating *information and communication technology* (ICT) and IoT technology in a secure fashion [1]. It is a vision to ameliorate human living, energy efficiency, economy, environment and governance [2]. There are increasing needs to improve the understanding of cities and their metabolism, and therefore using emerging technologies can facilitate its success. With the price reduction of sensor devices and the technology development of wireless transmission, data can be uploaded to cloud server via *wireless sensor network* (WSN) for intelligent cloud computing to generate meaningful information in a variety kinds of industry. The primary objective of this study is to create an IoT architecture for smart building construction that includes various aspects of intelligent management: intelligent space allocation, intelligent energy management, and intelligent safety, as exhibited in Figure 1 [3]. There are various fundamental elements for smart building infrastructures including smart energy grids and smart mobility systems. A *supervisory control and data acquisition* (SCADA) system typically plays the important role as a real-time engine to monitor the buildings in urban cities [4].

The IoT application platform is to provide a gateway to cloud software solution for IoT and cloud applications. Adapting IoT application platform to construct smart building, we can monitor and control facilities and environment parameters to save cost and protect safety [5]. Furthermore, we can use machine learning and big data analysis to extract useful information to support decision-making and creative applications.

In this paper, we explore the process of developing Smart City IoT applications from a coordination-based perspective. We show that a distributed coordination model that oversees such a large group of distributed components is necessary in building Smart City IoT applications. In particular, we propose Adaptive Distributed Dataflow, a novel Dataflow-based programming model that focuses on coordinating city-scale distributed systems that are highly heterogeneous and dynamic.

This study firstly reviews a number of smart building practices from the literature and analyzes its advantages and benefits. The case study involves reviewing smart building initiatives, H-building energy environmental design plan, and actual implementation result with performance. Some interviews are also conducted. When the building was built, we specifically verified six quantifiable green building indicators: 1) sustainable sites, 2) water efficiency, 3) energy and atmosphere, 4) materials and resources, 5) indoor environmental quality, and 6) innovation in operations and regional priority. Adopting IoT technology is a way to verify smart building validity. This develops a firm foundation for a sustainable development of smart cities in countries in future.

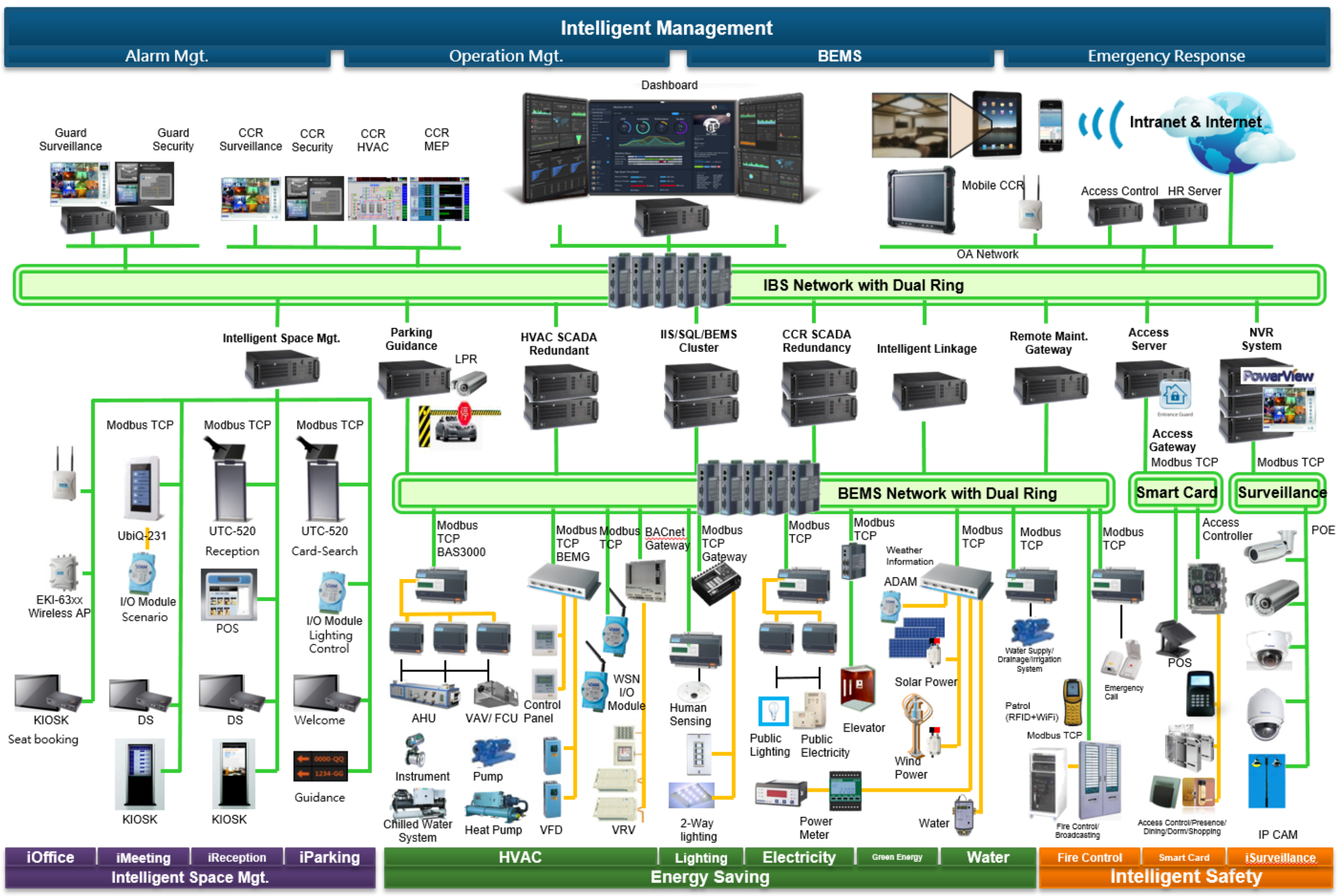

Figure 1. Integrated IoT architecture for smart building (Source: Advantech, 2017)

LITERATURE REVIEW

Smart Building

Smart building is an interactive node of the city network which is a structure using automated process to automatically control the building's operations including lighting, air conditioning, ventilation, heating, security and other systems [6]. The expectation of smart buildings is to get over facility management challenges and realize the potential of improved operational and energy efficacy by leveraging interdependency between building and business system, leading to optimized or automated facility management processes and providing a wealth of data for analysis [7]. In order to collect data and manage the different building operations based on specific business functions and services rules, a smart building uses sensors, actuators and microchips to realize its productive and cost-effective environment.

IoT Technology

The IoT is an information technology and the network of things that are connected to Internet corresponding among sending devices to enable data acquisition, transmission and processing and allow intelligent identification and management in cloud server [8]. In the IoT era, Internet-connected things provide an influx of data and resources that offer unlimited possibilities for applications and services [9]. Smart City IoT systems refer to the things that are distributed over wide physical areas covering a whole city [10]. While the new breed of data and resources looks promising, developing applications in such large scale IoT systems is a difficult task due to the distributed and dynamic natures of entities involved, such as sensors, actuating devices, people, and computing resources. Figure 2 shows the simple building central control technology architecture adopting IoT technology. As technologies advance, the definition of smart buildings is evolving continuously.

Figure 2. Simple building central control technology architecture

METHODOLOGY AND RESEARCH QUESTIONS

This study was conducted based on literature review in the library, online resources, and interviews with the system integrator for H-building [11]. The survey questions as follows. The remaining section discusses the analysis of the responses collected from the research process.

1. What is the original design of H-building (LEED project)?
2. What is the expectation of the end customer from the smart building project?
3. What are the advantages of adopting IoT technology for the smart building project?
4. What is the role of IoT application platform software in the smart building project?

H-BUILDING REVIEW

In 2010, the H-building was designed for green building which refers to both a structure and the application process that are environmentally responsible and resource-efficient throughout a building's life-cycle: from planning to design construction, operation, maintenance, renovation, and demolition [12]. Moreover, it was built in accordance with the requirements of LEED (Leadership in Energy and Environmental) [13]. The implementation of green building content requires the office air conditioning electromechanical system to meet international energy efficiency standards, indoor air quality to meet the comfort standards, and conform to the health requirements. Furthermore, H-building uses IoT application platform software for smart building solution to monitor and control water, energy and environment parameters.

LEED Project Implementation

The execution performance of a LEED project is as follows:

1. Indoor environment quality: (1) Indoor air quality monitoring. (2) Increase outside air ventilation and improve indoor air quality. (3) Use low-fugitive green building materials, such as uric acid-free and formaldehyde resin sheet. (4) The air wash before personnel stationed/worked in the room.
2. Sustainable design: (1) Using native and multi-planted landscape design to enhance base biological diversity. (2) Water retention design base to reduce storm runoff. (3) Set a bike seat, a total of parking spaces and green vehicles for parking spaces to encourage non-driving, car sharing and driving a low-pollution green car.
3. Energy-saving design: (1) Using ice storage, dual temperature system and high efficiency ice water host. (2) Using a side variable flow and high temperature difference system, ice water and cooling water pump. (3) High efficiency fan and outside air conditioner box frequency control. (4) Using high temperature contrast FCU. (5) Increase direct outside air to reduce air conditioning energy consumption (aving energy for process exhaust system). (6) Cooling tower water by frequency control. (7) Energy saving for lighting. (8) Set solar panels. viiii. Energy-saving efficiency of about 20.7%.
4. Water-saving design: (1) Daily water consumption decreased by 66%. (2) Set up "Rainwater Recovery Pool" to recover over 7,900 metric tons of rainwater annually. (3) Collect air-conditioning condensate and reclaim over 5,000 metric tons of condensate annually. (4) Use water-saving sanitation equipment to reduce water consumption. (5) After treatment of collected rainwater and air conditioning condensate, it will be used in latrines and plants for irrigation, saving more than 5,500 tons of water annually. (6) Use of native drought tolerant for Landscape Design.
5. Recycling resources: (1) Construction waste recovery rate of 76%. (2) Up to 17% of building materials with recycled components and 27% of local building materials.

H-building received Golden Certification in 2013 with a score of 62 points as shown in Table 1. The performance of H-building is as follows: (1) Energy efficiency is above LEED 13.7%. (2) Energy cost savings up to 20.7%. (3) Using rain and air conditioning condensate for planting is 100% replacement of tap water. (4) Using rain and air conditioning condensate to flush toilet and urinal is 100% replacement of tap water. (5) The overall daily water saving rate is 66% including toilet, urinal, faucet, and shower head. (6) The recycling or reuse of construction waste is up to 76.3%. (7) The building uses 17.4% recycle materials. (8) The building uses 27.52% local mining and processing material.

Table 1. Green Building Certification Score for H-building

	No.	Measureable items	Cert. Score (%)	H-building Score	Performance to LEED
	1	Sustainable Sites	20 (24%)	20	Higher than 13.7%
	2	Water Efficiency	10 (9%)	10	Save cost 20.7%
	3	Energy and Atmosphere	35 (32%)	12	100% use rain & air conditioning condensate to replace tap water
	4	Materials and Resources	14 (13%)	5	
	5	Indoor Environmental Quality	15 (14%)	5	Saving water rate 66%
	6	Innovation and Design Process	6 (5%)	6	Reuse or recycle 76.3%
	7	Regional Priority	4 (4%)	6	Recycle building material 17.4%
	8	Regional bonus		4	Local mining & process of building material 27.52%
			110 (100%)	62	Gold Certification (60-79)

IoT Application Platform for Smart Building

Smart buildings typically comprise numerous systems, such as air conditioning, electricity, lighting, demand control, safety, water, fire detection systems as shown in Figure 3.

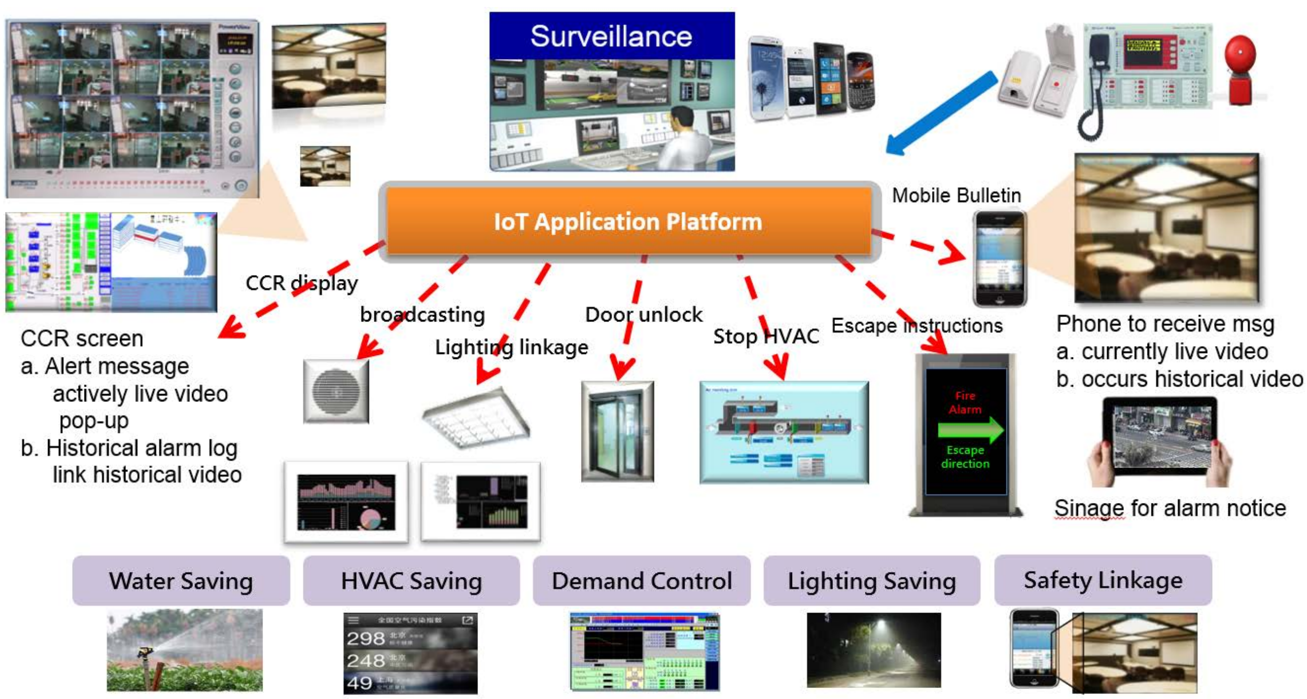

Figure 3. Smart building systems with IoT technology

The main body of the entire smart building structure is supported by IoT technology from nodes to cloud. It covers three major layers: *sensor layer* for obtaining data, *network layer* for data transmission, and *application layer* for data analysis. Data mining capabilities and applications are the keys to the SBIoT concept that support the interactions between people and the environment. The advantage is being able to use IoT application platform as the brain of the building to integrate various systems and application for real-time monitoring and controlling at anytime and anywhere.

CONCLUSION

While green building is a passive substrative engineering project, smart building is a proactive additive engineering project. In response to human being's expectations and needs, theses two engineering projects have created the basic appearance of a building in a smart city. With the coming of smart city, new life styles will overturn traditional ways of living. SBIoT offers people diverse and convenient living environment by utilizing IoT technologies with the integration of sensor devices, Internet transmission, cloud storage, big data analysis, valuable data extraction, and countless applications. Through the case of H-building, this study explains a smart building practice and discloses the environmental effectiveness and performance. If the SBIoT project is proven to save electricity or water consumption efficiently, it would be possible to promote adopting IoT application platforms in the households to the public for decreasing their monthly electric or water payment. We believe, through the use of the proposed architecture, urban smart building could be constructed better in the near future.

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