International Journal of Electrical, Electronic and Communication Sciences
ISSN: 2517-9438
Vol:11, No:3, 2017

Development of Energy Management System Based on Internet of Things Technique

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***Abstract*—**The purpose of this study was to develop an energy management system for university campuses based on the Internet of Things (IoT) technique. The proposed IoT technique based on WebAccess is used via network browser Internet Explore and applies TCP/IP protocol. The case study of IoT for lighting energy usage management system was proposed. Structure of proposed IoT technique included perception layer, equipment layer, control layer, application layer and network layer.

***Keywords*—**Energy management, IoT technique, Sensor, WebAccess

I. Introduction

THE energy management issue was a systematic on-going strategy for controlling a building's energy consumption pattern. It is meant to reduce the waste of energy to the minimum permitted by the climate where the building is located, its functions, occupancy schedules, and other factors. It establishes and maintains an efficient balance between a building's annual functional energy requirements and actual energy consumption. A university is an eclectic mix of building styles and construction, including research facilities, libraries, offices, auditoriums, dormitories, classrooms, dining halls, a central steam-heating plant, individual building chillers for air conditioning, and thousands of lighting fixtures and exit lights [1]. Hence, energy management is a major concern on university campuses.

Baytiyeh [2] developed the IoT primarily driven by the needs of large corporations that stand to benefit greatly from the foresight and predictability afforded by the ability to all fields. With the IoT technique to code and track objects, it has allowed companies to become more efficient, speed up processes, reduce error, prevent theft, and incorporate complex and flexible organizational systems [3]. The IoT was a technological change that represents the future of computing and communications, and its development depends on dynamic technical innovation in a number of important fields. Key goals for a IoT architecture to achieve were [4]: (1) an open, scalable, flexible and secure infrastructure for the IoT and people, (2) a user-centric, customizable 'Web of Things' including interaction possibilities for the benefit of society, and (3) new dynamic business concepts for the IoT including flexible billing and incentive capabilities to promote information sharing.

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II. The Model of IoT Technique

A. IoT Concepts

The IoT was a concept of network for information exchange and communication through extending or stretching its client to goods and goods on the basis of the Internet [5]. The IoT is so as it enables a set of things/objects to be [6]: (1) Pervasive: IoT devices can interact with the environment by sensing and then analyzing about data that is produced. These objects may be connected through wired or wireless networks. They can exchange information and interact with the environment for taking the best decision at real-time. (2) Identified via a unique address: The desirable characteristic is obtained by Internet Protocol Version (IPV), which grants an expanded addressing space. (3) Cooperative: IoT devices cooperate with other things by granting them an access to the local information to create new applications or services. The International Telecommunication Union (ITU) suggested the network architecture of IoT consists of (1) the sensing layer, (2) the access layer, (3) the network layer, (4) the middleware layer, and (5) the application layers [7].

B. The Structure of IoT Technique Based on WebAccess

The IoT technique based on WebAccess is a configuration software, which is based on network browser Internet Explore and applies TCP/IP protocol in the soft core. Thus, the open character of Internet becomes a basic part of the Advantech WebAccess system. The client can access the system, make dynamic online edit and master the information of the system by standard web browser without any restriction. Advantech WebAccess is one of the best Internet control schemes, with an infinite number of the clients. At the same time, the network safe scheme of Advantech WebAccess can also protect the data of users and the whole system.

WebAccess is a powerful software for graphical monitoring that is usable for designing and constructing a multifunctional human interface. It can be used for data collection, alert processing and reporting systems. The operational interface can be configured using mechatronics equipment and controllable I/O devices. This interface provides a number of graphical tools for user convenience. This research presents an automatic control system based on WebAccess software for intelligent buildings for distributed control and the centralized management of buildings [8].

Based on the literature review, the structure of the IoT technique in this study based on WebAccess control system includes (1) perception layer, (2) equipment layer, (3) control layer, (4) application layer, and (5) network layer. Fig. 1 shows the model of the IoT.

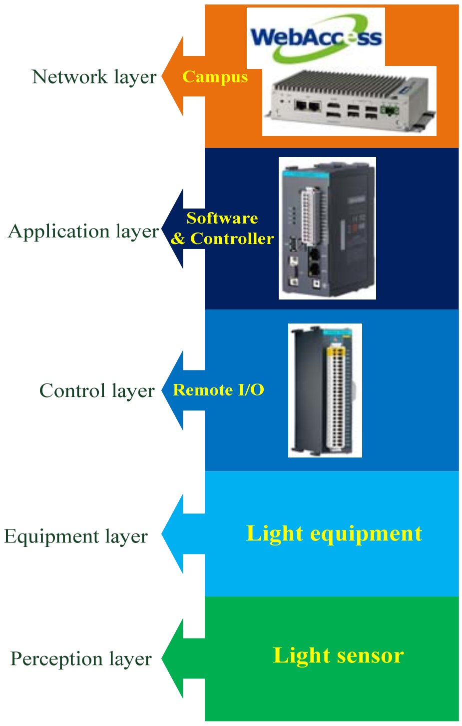

Fig. 1 The model of IoT

III. Energy Management System

The integration of sensing and actuation systems with Internet monitoring is probable to optimize energy consumption as a whole. It is expected that IoT system will be integrated into lighting energy consuming devices and be able to communicate with the utility supply company in order to effectively balance power generation and energy usage. Such a proposed system would also offer the opportunity for users to remotely control their devices, or centrally manage them via a Cloud-based interface, and enable advanced functions like scheduling.

Smart buildings and green buildings are the two topics of great importance currently in architecture/engineering education [9]. Between them, green buildings are capable of saving energy, saving water, protecting the environment and helping people to ensure sustainable development, while smart buildings are green buildings with better performance enabled by using information and communication technology (ICT), the IoT and other advanced technologies [10], [11].

Lighting controls are usually to reduce energy expense. Lighting controls or advanced load management is able to reduce lighting demand when energy is most expensive. Manual dimmers, which allow occupants to adjust light levels to their preference, are becoming more affordable. Lighting controls have been shown to reduce lighting energy consumption by 50% in traditional buildings and by at least 35% in new buildings [12].

The benefit of digital lighting control systems has their ability to monitor the operation of the lighting systems. At the minimum, the digital control system can receive feedback from each component, confirming that it is on or off as commanded. Using the digital control system, it can also monitor the number of hours that the lights are operated in a given area, as well as the number of times the lights are turned on, which are the most important factors in determining lamp life [13]. Using this information, managers can schedule the relamping of particular areas in the building before the number of lamp burnouts becomes excessive, while also ensuring that the lamps have been used for as long as possible.

IV. Application Results

This study proposed a case study of the IoT technique for lighting energy usage management. Fig. 2 is the block diagram of proposed system. The system was developed for a university campus in Taiwan. The system structure was composed of five layers: a network layer using WebAccess, an application layer using software and controllers, a control layer using remote I/O, an equipment layer using the lighting equipment, and a perception layer using light sensors. Fig. 3 is the snapshot of the web page for the energy management system, which provides a status overview of each wireless gateway of individual households in the university campus.

The energy management system has several functions which achieved the desired objectives. The main function is to turn the lights on and off, depending on the schedule table of the area and the occupancy pattern. The schedule table is downloaded from the university server at the beginning of each semester, for example, and the lights turn on in a classroom when two conditions are achieved together: (1) there is a lecture at this time, (2) the occupancy sensor detects a motion (the students enter the room); otherwise, the lights remain off even one of the previous conditions are verified. Through this scenario, this system can achieve maximum possible energy saving in the classrooms.

Through the system accounts, this study can make permissions for approved users. There are three permissions: administrator, instructor, and security. The administrator has the full privacy for editing, deleting, and modification of the system; the instructors also have privacies for monitoring and assigning new lectures, while limited permission is given to security.

The energy management system also supports other features, including the following: (1) Light meters that monitor the illumination in any room remotely using a data logging light meter, which is connected to the lighting panel through the serial port. (2) Daily load curves that display the load curve for any chosen room and calculate the total energy consumption for a specific day. (3) Energy management features that make energy conservation calculations at the university or any other facility, allowing users to print the specific outcome in tables, as well as a list of final results that indicate all forms of energy saving in the study. (4) The system can arrange all areas which have the same functions into a group to apply a blanket command to all of them at once. (5) The system can assign existing holidays, or any new holiday from the calendar, to apply a certain function to it.

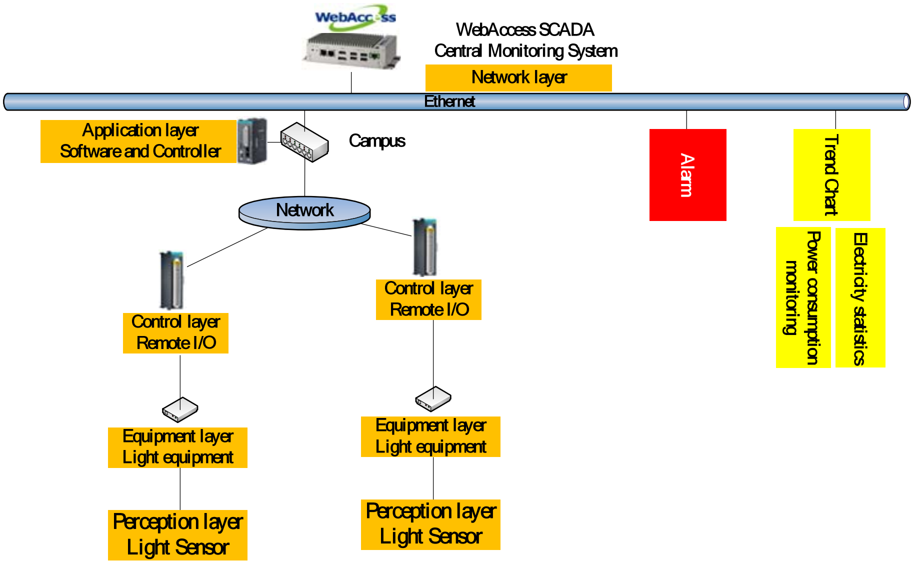

Fig. 2 The block diagram of proposed system

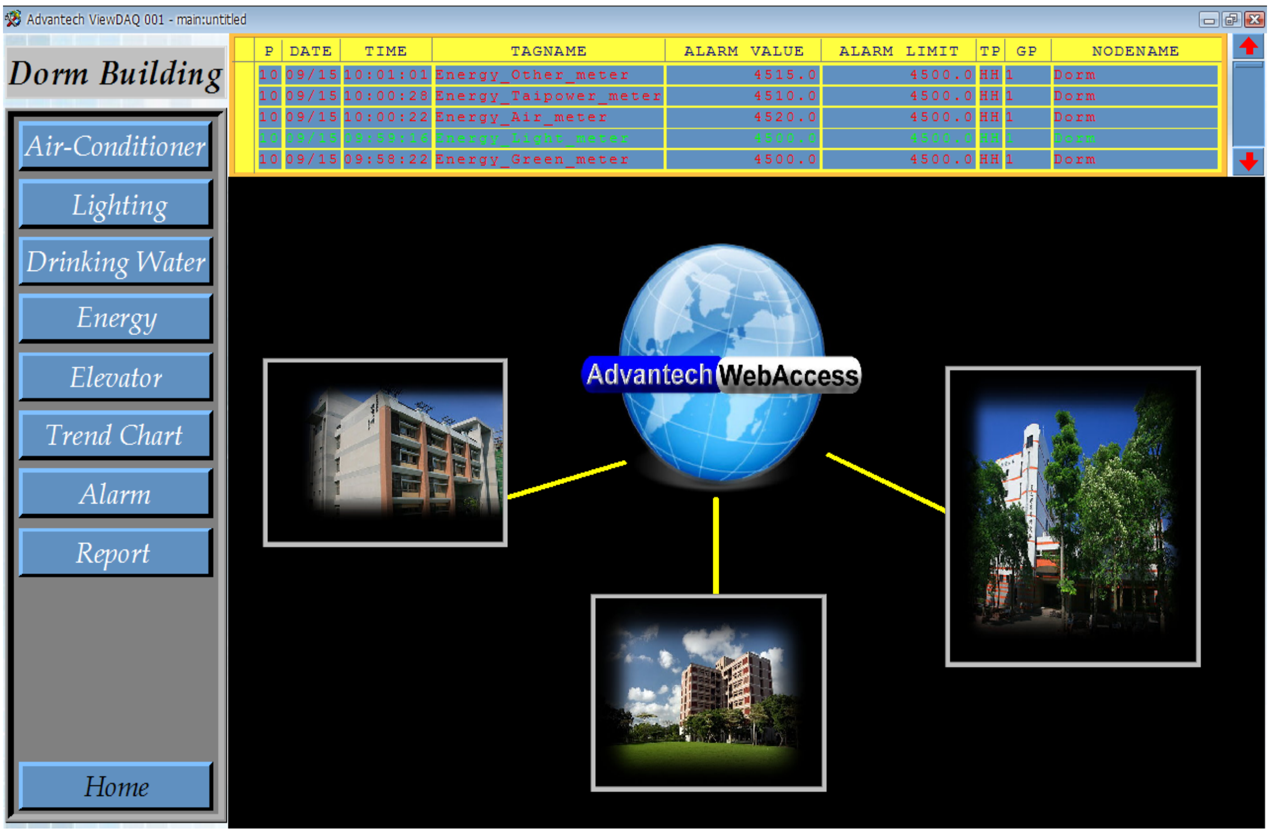

Fig. 3 The web page of management system

V. System Learned and Limitations

Several systems learned can be found and limitations have been recognized in the process of development and deployment of the lighting control management system.

A. Data Access Authorization

During the deployment process, the administrator was quite concerned as to how the collected data was used. However, the authorization is not transparent to administrator and any further extension of the data usage scope would need to be discussed. The current practice needs face to face explanation and discussion; thus, such a process for alterations could take a long time to settle. Potentially, the concept of the IoT cannot be realized and the system can only serve designated applications. One feasible solution is to enable the data owner to timely authorize the data access with concise information via the management system.

B. A Single Data Access Interface

The current implementation separates the real-time data access interface and the historical data access interface. It poses a difficulty to the IoT application development to use IoT data. In order to speed up IoT application development, it is desirable to have a single data access interface.

C. A Single Failure Point

The current proposed system has a single failure point at the central database. No applications could be available if this central database was blocked for some reasons. Therefore, a distributed database or an in-network database might be a solution that could remove this single failure point in the IoT system.

IV. Conclusions

This study proposed a case study of the IoT system for lighting energy usage management. The energy management system was developed for a university campus in Taiwan. With the application of the IoT technique based on configuration software WebAccess, the energy management system provides complete automatic monitoring, automatic adjustment, self-diagnosis, automatic alarm function, etc. All of these advantages can greatly reduce the number of equipment operators and operational costs, as well as improve management efficiency of lighting energy usage. In terms of the research contribution, the system learned and limitations have been summarized. Moreover, the research on the light control equipment in the building's application is specially introduced in this study. With further research, other energy management systems will be used in intelligent buildings.

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