CPS based Smart Home Power Management System

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***Abstract*—This Cyber-physical system (CPS) is a new technology to bring computational intelligent to physical devices and to make them mission- and situation- aware. It is deeply integrating computation, communication, and control into physical systems. CPS can be considered as the evolution of embedded systems into smart objects that will be joined together to create highly distributed systems, bringing a wealth of opportunities and innovations in technology, applications and business models. The core of the proposed system is the context-aware dynamic power consumption in near real-time and automatic controlling the power of the home by illuminating the cloud-assisted architecture and sensor measurement. Power measurement data sensing in near real-time is sent from the homes in the city to the Cloud and these data are used to compute the total actual power consumption of the whole city. Every city assigns their available power in the database server in the Cloud and can analyze their power usage. If the power consumption of the city is exceeded its available power, the power controlling application in the Cloud will send the message to the homes. The home users can notice this information from an email message or web-service and according to the received data, home users can take proper actions for unnecessary power using in real-time. The priority of the power usage will be regarded in the Cloud where the Health Care Center is the highest priority of applying the power and this information will also be stored in the Cloud to manage the level of the power usage system. If the users forget to make the proper actions to the appliances even they got the alert message, the controller will automatically power down to the lowest priority level in the City to prevent unnecessary power shortage condition in the house.**

Keywords—context-aware; cloud-assisted architecture; sensor measurement

I. INTRODUCTION

A cyber-physical system (CPS) is an integration of computation with physical processes. Recently, the community has come to understand that the principal challenges in embedded systems stem from their interaction with physical processes, and not from their limited resources. The term cyber-physical system (CPS) was coined by Helen Gill at the National Science Foundation in the U.S. to refer to the integration of computation with physical processes. In CPS, embedded computers and networks monitor and control physical processes, usually with feedback loops where physical processes affect computations and vice versa. The design of such systems requires, therefore, understanding the joint dynamics of computers, software, networks, and physical processes [1].

Due to the fast growth in technology, automation based systems are playing important role in our day to day life. Introduction of intelligent system and smart devices helps to save time, provides automatic control, reduce the human effort, eliminates the human error and reduce the energy wastage. Building automation system or intelligent building system in residential and commercial complexes is popular due to safety, security and efficient energy management.

Due to human crave for sophistication and automation, industries with energy management and security system have become very popular and demanding. Solutions include building automation, video surveillance, efficient monitoring, fire protection and control of heating, alarm systems and many more. In order to obtain industry automation and energy management, Systems need to work as a single unit with cohesive nature. This will provide increased performance with intelligent control.

The above mentioned operations can be performed with various ways, such as manual, electronic or computerized. Computerized approach is superior to other ones. A computerized system can perform interactions with objects in the physical world is called cyber-physical systems (CPS) which are integrations of computation and physical processes [2]. No matter what approach is used in constructing smart homes; the key point is human- centric that is serving human live in. Therefore, a smart home is an application of human-centric sensing because some sensors are deployed in.

II. RELATED REVIEW

As mentioned, others have investigated the other classes of cyber-physical systems. Parthasarathy Guturu and Bharat Bhargava in [3] were able to highlight the characteristics of a CPS, state-of -the-art in CPS research, CPS challenges and opportunities for solving complex application problems.

Mr. NitinGaikwad, Amol Mane, PopatKharade, AbhijitKashid in [4] demonstrated a web based control of electrical appliances through the Ethernet connectivity. They promote the control of electrical appliance from the web server by using LM3S8962 stellaris family microcontroller.

Borse Bhagyashree, Smita Kulkarni, R.D.Patane in [5] described a technology that can perform remote control and monitoring of electrical appliances on the Internet. Intelligent power socket (IPS) module is implemented and which is placed in conjunction with the electrical appliances that are to be controlled from a far-end place. In addition, an embedded

system based home gateway that can be connected with the Internet is set up and the acquired power consumption information or the status of the appliances is stored in a database server in the Cloud. The control command from the far-end place, i.e., from the web server on the Internet, is first sent to the home gateway and then transmitted to the IPS modules through the Zigbee wireless communication protocol so that the remote control of appliances can be achieved.

Marvin R. G. Garcia, Hannah R. B. Chan, Benilda E. V. Comendador, Grant B. Cornell, Christopher D. Celestial, Arc E. P. Mercolesia in [6] demonstrated Cloud Computing based Smart Home Electricity Management System. It can collect on-line data power consumption, and can manipulate the power supply of the connected electrical appliances through the Internet. It enables the consumer or establishment to keep track the real-time power consumption which allows users to save electrical energy.

Peng Zhao, M. Godoy Simões, Siddharth Suryanarayanan in [7] presented a conceptual framework for a cyber physical system for energy management in building structures, with the intent of increasing energy efficiency, lowering dependence on the grid, and providing an economic incentive for the end user. Integrating renewable energy sources and distributed generation sources will be critical to the success of the ideas in the paper. Energy storage is also expected to be an integral part of the solution to energy efficiency, especially when considering renewable energy sources with erratic input such as solar and wind. The overall goal of the system architecture is to increase energy efficiency and reduce environmental impacts.

Saher Umer, Yasuo Tan, and Azman Osman Lim in [8] investigated the stability analysis for smart homes energy management system with delay consideration. In the paper, they focus on achieving optimal system model for smart homes to reduce the risks of power blackout by applying two different criteria of power assignment for the home appliances. They carry out the stability analysis and verify that system stability is dependent on some time delay.

A. Problem Statement

Our world is suffering energy crisis on oil and natural resources shortages, how to make efficient use of limited power energy has remained a major problem to be conquered so far. As more and more home appliances and consumer electronics are installed, residential energy consumption tends to grow rapidly. The proposed system aims to facilitate the life of human being as well as to use the limited power energy more efficiently.

B. Motivation

In these existing studies, there is a lack of implementing open source Cloud based power management system and controlling the home power system by the application system in the Cloud. This is our main contribution and will be found that individual power controller needs not be implemented in each home to prevent unnecessary power shortage condition for each home.

III. Research Objective

In particular, the objective of this research is to implement the stability of Home Power Management System based on the following tasks:

- To develop a practical CPS approach for home power management system.
- To design the Cloud-based home power management system by continuously sensing the dynamically changing near real-time power data.
- To illustrate a different way to control of a home energy management technology using the cloud network.
- To handle the power shortage condition with the help of Cloud database server and the power controlling Apps implementing in the Cloud.

IV. Proposed System design

Fig.1 shows the overview design of the proposed system for CPS based Smart Home Power Management System. The main theme of this system is managing the power of the smart homes in the city. Every smart home will have power consumption measurement sensor (smart power meter) which will sense dynamically change power consumption data in near real-time and the data will be sent as a sensor data to the Cloud by applying the intervening controller.

Power management controller implemented by software approach is kept in the Cloud and which will be responsible for computing the total actual power usage of the city. If the actual power usage is over the critical value which is already stored in the Cloud database, the controller will send the alert information to the smart home user in real-time so that the users can have the chance to take proper actions to reduce power consumption. Web-based monitoring and control systems will be developed to enable users to view home energy data and control home devices through the Internet.

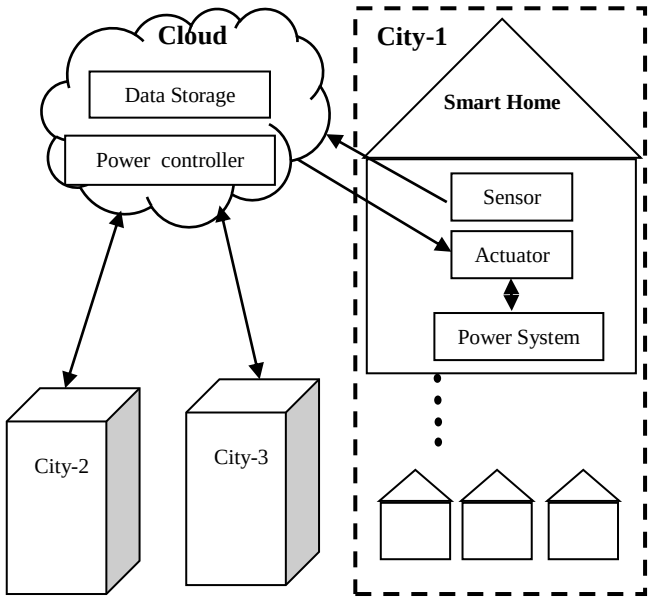

Fig. 1. Overview design of the proposed system.

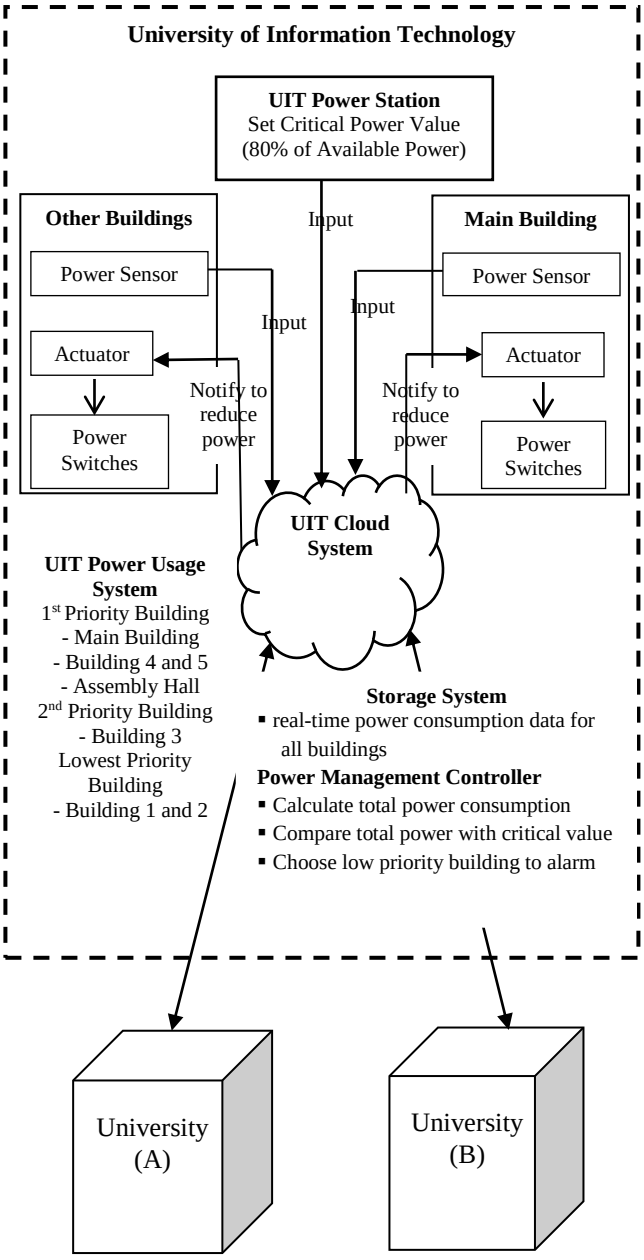

Fig. 2. Preliminary design of power management system.

In this research, the proposed system will be preliminarily implemented for managing the university power system. The power sensor is kept in each building and the sensor data will be stored in the university Cloud database. In this study, power management controller is targeted for the buildings in the university compound. If the excessive power using is found, the controller in the Cloud will facilitate controlling the building power switches based on the priority level of the building to prevent the power shortage condition as shown in Fig.2. Moreover, the other universities can readily apply this power management controller in the Cloud without implementing the individual controller in other universities. Therefore the research target is designing an open source power management controller which will give as a Cloud service.

V. Conclusion

While home automation systems undoubtedly provide immense benefits in terms of convenience, more work needs to be done to ensure robust and secure designs of these systems. Furthermore, there is a need for all stakeholders involved ranging from industry and research partners to homeowners to fine-tune our understanding of whatever flaws these systems possess.

Particular interest of this system is that investigating a picture of near real-time actual power consumption of the smart home and managing the power usage of the city with the help of the control unit in the Cloud system. The expected advantages of this system is that users may have the chance to know near real-time power consumption and can take proper actions to their electrical appliances to reduce power consumption and also the city can manage the actual deliverable power to smart building and can announce the over power consumption information to the smart home users in real-time.

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