A Review of Smart Power Monitoring and Controlling System in View of an Intelligent Building

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ABSTRACT:

This paper provides a survey on implementing wireless sensor network (WSN) technology based on smart monitoring and controlling mechanism of household electrical appliances in different ways. For this purpose we briefly discuss the existing power management in smart homes/building, following with a review of advantages of adopting WSN technology for power management. Then it focuses on challenging factors influencing the design and development of WSN based power management and also on solutions for power management. It also provides improvements for further research.

Keywords: Wireless sensor network, Energy management, Smart home, Home automation, Intelligent control system, Reliability.

I. INTRODUCTION

Today, we are entering the third wireless revolution, known as "Internet of things", in which the description about the integrated network architecture and interconnecting mechanism for reliable measurement of parameters by smart sensors and transmission of data via internet is being presented. The dream is to automatically monitor and respond to forest fires, faults in country wide utility equipment, Traffic, hospitals and much more over wide areas and with billions of sensors.

In this technological world the electric power is the main source for the development and advancement. The technology develops the power requirement and increases the power demand. These power demands occur in both domestic and industrial sectors. As we have seen that more and more home appliances and consumer electronics are installed, residential energy consumption tends to grow rapidly. These large no. of home devices increase power consumption. With the advancements and rapid expansion of internet technologies and WSN in recent years the home environment has seen a rapid introduction of network enabled digital technology which offers new and exciting opportunities to increase the connectivity of devices within the home for purpose of home automation.

In recent years, wireless sensor networks (WSNs) used for environmental monitoring, health monitoring and industrial monitoring has been widely recommended as a means of reducing the energy consumption and CO2 emissions (S). WSNs are also highly flexible. Wireless sensor network technology has demonstrated a great potential for industrial, commercial, and consumer applications. Specifically in management, control and collecting data such as pressure, humidity, temperature, flow, level, electrical parameter etc. can be collected through sensing units and transferred wirelessly to a control system for operation and management. Adopting WSNs for power management provides great advantages over traditional wired system. However, WSN technology is not considered mature enough to be widely implemented in power management applications.

In last The objective of this paper is to review the existing works about smart home systems based on the wireless communication technology and try to avoid the uncomfortable situations like peak hour power cut in industrial and domestic areas by giving a solution to the power demand and energy management.

A. Paper Organization

The rest of the paper is organized as follows: section II discusses related work and also investigation of smart home energy management system based on wireless sensor network. Section III discusses some limitations with respect to home automation system and also how to overcome these limitations, this section also provides some functions of the smart home power monitoring and controlling system. Section IV concluded and discussed about the future work.

II. LITERATURE REVIEW

In this section, we briefly discuss the existing works about smart home system based on the wireless communication technology.

Wireless sensor networks have become increasingly important because of their ability to monitor and manage situational information for various intelligent services. X.P.Liu, W.Gueaieb, S.C.Mukhopadhya, W.Warwick and Z.Yin reports some of the latest theoretical developments and applications in this fast-growing area. Mechatronic systems will become more and more ubiquitous at home in near future and will be very useful in assistive healthcare particularly for the elderly and disable people. Wireless mechatronic devices, services, and systems consisting of spatially distributed autonomous sensors are used to monitor globally or locally physical or environmental conditions, such as temperature, vibration, pressure, motion etc. [1].

Distributed unattended ground sensor networks used in battlefield surveillance and monitoring missions, have proven to be valuable in providing a tactical information required for command and control, intelligence, surveillance, and reconnaissance planning. Darminder s. Ghataoura and John E. Mitchell, University College London George E. M atich, Selex Galileo Ltd [2] Present a cross-layer approach and highlight techniques that have potential to enable NCC operation within a mission-oriented UGS surveillance setting.

P.Cheong, K.F.Chang, Y.-H.Lai, S.-K.Ho, I.-K.Sou and K.-W.Tam [3] has presented a low cost and low power Zig-bee based WSN node for the UV detection of flame, contributing to the fire safety protection industry. In this context, this paper reports a WSN node for safety and also they characterized the emission spectrum from flames using a spectroscopic technique. Radiations from a common hydrocarbon flame are analyzed and used as flame reference of this study. The presented flame detection can be easily integrated with building or facility management system at low cost.

WSN also has been applied in healthcare fields. Advances computer and communication technology have enabled online healthcare monitoring using miniature sensing devices attached to patient's body. Data collected in this manner is delivered in real time trough one or more wireless hopes to the hospital network. J.Misic and V.B.Misic [4] present an article in which they discuss design alternatives for the wireless portion of an online healthcare monitoring system and present performance results for a two-tier network that uses IEEE 802.15.4 low data rate wireless personal area networking (WPAN) for the patient's body area network and IEEE 802.11b for the connection between the body area network coordinators and the wired portion of healthcare system.

The WSNs are increasingly being used in the home for energy controlling services. M.Erol-Kantarci and H.T.Mouftah [5] presented an approach in which regular household appliances are monitored and controlled by WSNs installed in the home. New technologies include cutting-edge advancements in information technology, sensors, metering, transmission, distribution, and electricity storage technology, as well as providing new information and flexibility to both consumers and providers of electricity.

To create smart homes that improve energy management and efficiency [6] the ZigBee Alliance, wireless communication platform is presently examining Japan's new smart home wireless system implication by having a new initiative with Japan's Government that will evaluate use of the forthcoming ZigBee, Internet Protocol (IP) specification and the address zig-bee module IEEE 802.15.4g.

In the country like United States (US) some areas such as California and Texas, smart meters are almost fully deployed. From June 2011, 20 million i.e. 50 percent of all households equipped with smart meters and it is expected that the number will increase to approximately 65 million Meters by 2015.It is realistic estimate of the size of the home energy management market [7].

A smart grid which is an enhancement of 20th century Power grid is an opportunity to use new information and communication technology to revolutionize the electrical Power system. At present many countries have put forward their own "Smart grid" plans and the intelligence of client is one study focus. As the footstone of smart grid in client and grid intelligent management, AMR (Automatic meter reading) system play an important role. L.Li, H.Xiaoguang, H.Jian and H.Ketai [8] proposes Wi-Fi based new type of network architecture for new generations AMR system and researches its protocols and topology optimization of cluster formation.

Andrey E and Morelli J [9] state that, by the 2010 Ontario ministry has mandate to use smart energy meter for residence home. To use smart meters, a techno-economic model comparing various functionality levels of meters has been designed. They had developed three different functionality smart meter for this study: Minimum Functionality Smart Meters, Smart Meters with In-Home- Display, and Smart Meters with a Demand Control Unit. Based on this case studies, it was observed that using smart meters with a minimum functionality level was most profitable. However, it was also observed that the greatest reduction in energy usage during peak demand periods occurred when demand control units were incorporated into the system

Dae-Man Han and Jae-Hyun Lim Member [10] contributes work towards the development of ubiquitous home networks, energy savings and user happiness are two major design considerations for modern lighting systems. This paper introduces smart home interfaces and device definitions to allow interoperability among Zig-bee devices produced by various manufacturers of electrical equipment, meters, and smart energy enabling products. They introduced the proposed home energy control systems design that provides intelligent services for users and also demonstrate its implementation using real test bed.

Kamat, V.N [11] demonstrate the use of smart LT apparent energy meters for effective reduction in ATC losses. The technical component is reduced through the implementation of a fair apparent energy based tariff. This is an

elegant single parameter (unit KVAh) based tariff that incorporates an embedded power factor based discount mechanism to offer a Win-Win solution, where consumers can avail discounts in their electricity bills while the utilities minimize their line losses through reduction in harmonics and inductive loads.

In order to fulfill the energy saving targets and also for optimal power utilization, F.Benzi, N.Anglani, E.Bassi and L.Frosini [12] have been proposed different information and communication technologies which is integrated with smart meter devices which has advanced value added services so that home inhabitant can take advantages from meter information, like optimal heating, air conditioning or lighting based on actual energy tariff and also tested at different flats in a residential areas.

I.Kunold, M.Kuller, J.Bauer, and N.Karaoglan [13] describe a system concept of energy information system in flats using wireless technologies and smart metering devices. Smart meters offer a lot of new features, for example handling of different dynamic tariffs and in addition to their carrier interface a data access capability for in-house applications. Using these capabilities an embedded in-house energy information system with a smart energy controller (SEC) will be proposed, which allows displaying real-time data information and analysis of power consumption.

J.Han, C.S.Choi and I.Lee. [14] proposed a Home Energy Management System (HEMS) using the ZigBee technology to reduce the standby power. This system consists of a ZigBee hub, a server and automatic standby power cutoff outlet. The central hub collects information from the power channels and controls these power channels through the ZigBee module. The central hub sends the present state information to a server and then a user can monitor or control the present energy usage using the HEMS user interface. The power outlet with a ZigBee module cuts off the ac power when the energy consumption of the device connected to the power outlet is below a fixed value. Some type of uneasiness may also be created by this system like if the users may want low intensity of light, for some situation but the system will cut the power off leading to darkness.

K.Gill, S.H.Yan, F.Yao [15] presented a ZigBee-based home automation system in which less importance is given to the home automation. Because however the adoption of home automation system has been slow so that this paper identifies the reason behind slow adoption and also evaluates the potential of zig-bee for addressing these problems with the help of design and implementation of a flexible home automation architecture.

M.S.Pan, L.W.Yeh, Y.A.Chen, Y.H.Lin and Y.C.Tseng [16] presented A WSN based intelligent light control system considering user activities and profiles. In which wireless sensors are responsible for measuring current illuminations and the lights are controlled by applying the model of user's actions and profiles for indoor environments, such as a home for a reduction in energy consumption.

Song *et al*. [17] presented the design and implementation of a home monitoring system based on hybrid sensor networks. The system follows a three-layer architecture which combines hybrid-node networking with web access. An enhanced sensor node has been designed and fabricated to add controlled mobility to wireless sensor networks. Network repair and event tracking capabilities of the mobile sensor node were tested. Stability of the proposed system in long time home monitoring tasks was also verified.

Suh and Ko [18] proposed an intelligent home control system based on a wireless sensor/actuator network with a link quality indicator based routing protocol to enhance network reliability. It can integrate diversified physical sensing information and control various consumer home devices, with the support of active sensor networks having both sensor and actuator components.

Nguyen *et al*. [19] have proposed building a smart home system with WSN and service robot. In which they have presented the design of optical linear encoder(OLE) based system for function of capturing human arm motion and arm function evaluation for home based monitoring and this system would also find wide range application in field of rehabilitation.

N.K.Suryaveda and S.C.Mukhopadhyay [20] reported the design and development of smart monitoring and controlling system for household electrical appliances in real time, in which it emphasizes the realization of monitoring and controlling of electrical appliances in many ways. They determined the areas of daily peak hours of electricity usage levels and come with a solution by which we can lower the consumption and enhance better utilization of already limited resources during peak hours.

N.K Suryadevara and S.C.Mukopadhyay [21] reported a mechanism for estimation of elderly well-being condition based on usage of house-hold appliances connected through various sensing units. This paper defines two new wellness functions to determine the status of the elderly on performing essential daily activities. The developed system for monitoring and evaluation of essential daily activities was tested at the homes of four different elderly persons living alone and the results are encouraging in determining wellness of the elderly. In this research wellness is about well-being of elderly in performing their daily activities effectively at their home. This will facilitate the care providers in assessing the performance of the elderly activities doing independently. The developed home monitoring system using WSN is low cost, robust, flexible, and efficiently monitor and assess the elderly activities at home in real time.

III. LIMITATIONS AND FUNCTIONS

The above mentioned home monitoring and controlling systems have limitations with respect to true home automation such as: 1) Only several household appliances can be controlled because power consumption control mechanism is limited to certain devices like light levels or illuminance. 2) It is not applicable to different consumers because energy control is based on fixed threshold power consumption. 3) Home appliances controlling through network management functions, in practice inhabitant requirements may vary according to their behaviour but not

with network characteristics. Not a single system has taken into consideration of variable tariff of electricity, which is consumed throughout day and night.

Overcome of limitations:

These limitations can be overcome by making some changes in reviewed system, like in first case if we use the sensing and load driver as per the power rating of appliances then we can controlled different devices other than household appliances. In second case we can change the value of threshold power consumption according to the requirement of consumers which is technically done by making particular changes in programming. If we consider the third case then it may overcome by giving the flexibility for the power consumption and variable tariff of electricity.

Functions of the Smart home power monitoring and controlling systems:

- Collect real time energy consumption from smart Meter and power consumption data from various in-house objects.
- Control activation/deactivation of appliances.
- Generate dashboard to provide feedback about power usage.
- Provide control menus to control appliances
- Provide a link to the utility and/or Internet.

IV. CONCLUSION AND FUTURE WORK

WSN is a technology with promising future and it is presently used in a wide range of applications to offer significant advantages over wired system. WSN technology is considered mature enough to be widely implemented in smart homes.

This paper has presented a survey on existing works about smart home system based on wireless communication technology, which was proposed by researcher. This overview of smart home system focuses on implementation, usability and challenges. Smart power monitoring and controlling systems allow every point of the smart home to be connected and controlled from a central point, enabling power efficiency and energy optimization. Leveraging the deployment of communications-enabled smart electricity meters, many applications can be offered to home owners for optimizing overall energy management, and to utility companies as a means of managing the load of their grid and preventing power demand peaks. Smart power monitoring and controlling systems are the interface between the utility-controlled smart grid and energy consuming in-house objects.

Future research and development may continue to be focused on further improvements of the reliability, responsiveness and technology advancements on energy saving, power management and fault tolerance.

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