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Wi-Fi Based Wireless Smarter Home Energy Management

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Abstract:
A Home Energy Management (HEM) system plays a crucial role in realizing residential Demand Response (DR) programs in the smart grid environment. It provides a homeowner the ability to automatically perform smart load controls based on utility signals, customer's preference and load priority. This paper presents the hardware demonstration of the proposed HEM system for managing end-use appliances. The HEM's communication time delay to perform load control is analyzed, along with its residual energy consumption.
Key words: *Microcontroller ,EEPROM ,Ethernet, Zigbee*

I. Introduction

Traditionally, in the U.S. and in many parts of the world, there is a persistent problem of inefficient use of electric power generation and transmission assets. For example the Dominion Virginia Power's service area, roughly 20% of generation assets are used 5% of the time [1]. This problem has partially been tackled by demand side management, which was introduced in the early 1980s With the introduction of the smart grid, it is now possible to perform demand response at customer premises to get a finer control of the available re-sources. Demand response (DR) is defined as "changes in electricity use by demand-side resources from their normal consumption patterns in response to changes in the price of electricity, or to incentive payments designed to induce lower electricity use at times of high wholesale market prices or when system reliability is jeopardized" [4]. According to FERC, DR activities in the U.S. are classified as either incentive-based (e.g., direct load control) or time-based (e.g., dynamic pricing, critical peak pricing) programs. FERC has also pointed out that almost 80% of the total U.S. peak load reduction potential comes from incentive-based DR programs .Due to this reason, and the fact that there has not been a mature time-varying tariff for residential customers, the DR concept for our hardware demonstration is based on the incentive-based DR program which involves a customer receiving some sorts of load control signals from a service provider. This DR concept is thoroughly discussed in , in which we describe algorithm to manage multiple power-intensive loads in a house to meet certain peak reduction targets, taking into account homeowner preset load priority and comfort level preference. In this case, a homeowner has the freedom to choose what loads to manage and for how long. This is different from a pre-set load (kW) reduction target set by a local electric utility company in direct load control programs. Note that for this kind of DR programs, economic incentives should have already been written into the contract between consumer and the utility. I n order to realize the proposed DR feature, it is necessary to deploy a fully automated DR solution, or auto-DR which can be made possible through the use of a Home Energy Management (HEM) system. Today, interests in HEM systemshave grown significantly. Various HEM systems are designed based on different communication schemes, such as ZigBee and power-line carriers [8]. In [9], authors implement an HEM system using a task-scheduling approach; while in ,authors propose an HEM system that can display energy usage information of individual appliances. In , authors propose an in-home energy management (iHEM) system to reduce energy expenses and peak loads. In authors focus on scheduling and controlling in-home appliances to provide economic advantages for residential energy management.

I. The Hardware System

Micro controller: This section forms the control unit of the whole project. This section basically consists of a Microcontroller with its associated circuitry like Crystal with capacitors, Reset circuitry, Pull up resistors (if needed) and so on. The Microcontroller forms the heart of the project because it controls the devices being interfaced and communicates with the devices according to the program being written.

ARM7TDMI: ARM is the abbreviation of Advanced RISC Machines, it is the name of a class of processors, and is the name of a kind technology too. The RISC instruction set, and related decode

mechanism are much simpler than those of Complex Instruction Set Computer (CISC) designs.

Liquid-crystal display (**LCD**) is a flat panel display, electronic visual display that uses the light modulation properties of liquid crystals. Liquid crystals do not emit light directly. LCDs are available to display arbitrary images or fixed images which can be displayed or hidden, such as preset words, digits, and 7-segment displays as in a digital clock. They use the same basic technology, except that arbitrary images are made up of a large number of small pixels, while other displays have larger elements.

MEMS: Accelerometers are acceleration sensors. An inertial mass suspended by springs is acted upon by acceleration forces that cause the mass to be deflected from its initial position. This deflection is converted to an electrical signal, which appears at the sensor output. The application of MEMS technology to accelerometers is a relatively new development.

GSM modem Section: This section consists of a GSM modem. The modem will communicate with microcontroller using serial communication. The modem is interfaced to microcontroller using MAX 232, a serial driver.

PC Section: This section basically contains a PC with Serial communication associated hardware. Apart from this, the web cam is also connected to the PC. The serial communication associated hardware circuitry includes the bus (DB 9) connector from PC to Microcontroller.

II. Design of Proposed Hardware System

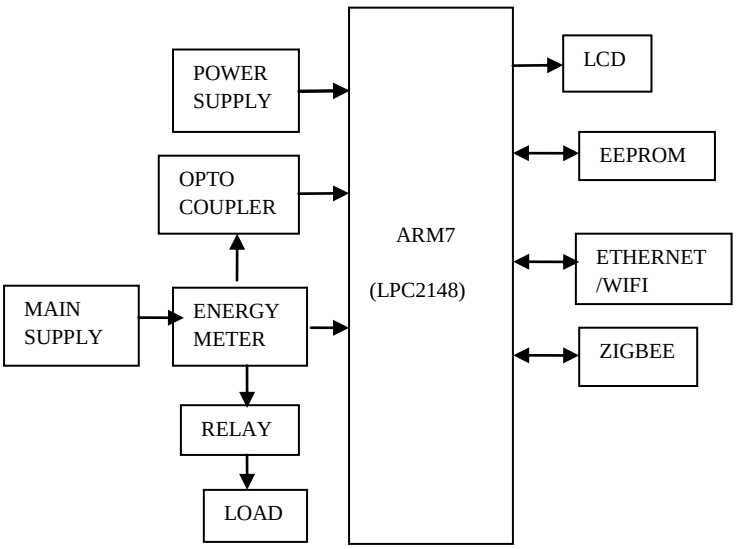

Fig.1.Block diagram

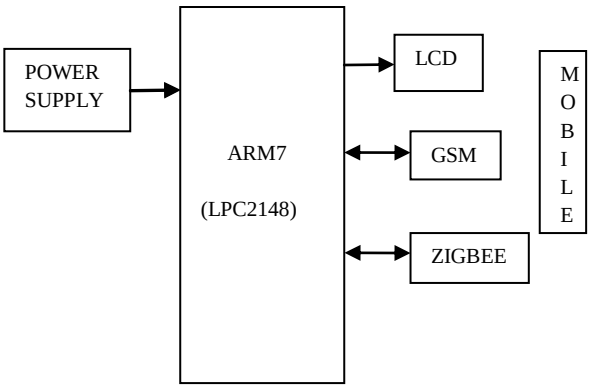

Fig.2.Block diagram

HEM system comprises *an HEM unit* that provides monitoring and control functionalities for a homeowner, and *load controllers* that gather electrical consumption data from selected appliances and perform local control based on command signals from the HEM system. A gateway, such as a smart meter, can be used to provide an interface between a utility and the data base for the electrical consumption is also maintained through internet

IV.Board Hardware Resources Features

Ethernet

Networking is playing vital role in current IT era where data distribution and access is critically important. As the use of communication between two or more entities increases the networking technologies need to be improved and refurbished over time. Similarly the transmission media, the heart of a network, has been changed with the time improving on the previous one. If you know a little bit about networking you surely have heard the term Ethernet which is currently the dominant network technology. Wide spread of the Ethernet technology made most of the offices, universities and buildings use the technology for establishment of local area networks (LANs).

To understand what actually Ethernet is, we need to know about IEEE first which is a short of Institute of Electrical and Electronics Engineers. IEEE is a part of International Organization for Standardization (ISO) whose standard IEEE 802.3 is defined for Local Area Network. The standard 802.3 commonly known as ETHERNT defines the communication standards for how data is transferred from one network device to another in a local area network. Since the limit for Ethernet cable is few hundred meters Ethernet is commonly deployed for networks lying in a single building to connect devices with close proximity. The same standard for Ethernet enables manufactures from around the earth to manufacture Ethernet products in accordance with the ISO standards that are feasible for all computing devices worldwide

ZigBee

ZigBee is a specification for a suite of high level communication protocols using small, low-power digital radios based on the IEEE 802.15.4-2003 standard for Low-Rate Wireless Personal Area Networks (LR-WPANs), such as wireless light switches with lamps, electrical meters with in-home-displays, consumer electronics equipment via short-range radio needing low rates of data transfer. The technology defined by the ZigBee specification is intended to be simpler and less expensive than other WPANs, such as Bluetooth. ZigBee is targeted at radio-frequency (RF) applications that require a low data rate, long battery life, and secure networking. ZigBee is a low-cost, low-power, wireless mesh networking standard. First, the low cost allows the technology to be widely deployed in wireless control and monitoring applications. Second, the low power-usage allows longer life with smaller batteries. Third, the mesh networking provides high reliability and more extensive range.

It is not capable of powerline networking though other elements of the OpenHAN standards suite promoted by openAMI and zdeal with communications co-extant with AC power outlets. In other words, ZigBee is intended not to support powerline networking but to interface with it at least for smart meeting and smart appliances purposes. Utilities, e.g. Penn Energy, have declared the intent to require them to interoperate again via the openHAN standards.

EEPROM

In the design of all microprocessors-based systems, semiconductor memories are used as primary storage for code and data. Semiconductor memories are connected directly to the CPU and they are the memory that the CPU first asks for information (code and data). For this reason, semiconductor memories are sometimes referred to as primary memory

Conclusion

In this paper, the demonstration of the proposed HEM system based on ZigBee is presented for residential DR applications ,along with the analysis of the communication time delay and the evaluation of the overall HEM system's residual power consumption. The objective of this demonstration is to evaluate the HEM operation performance, in particular how each load performs when being controlled by the HEM unit. Electrical measurements of the four loads understudy are presented, including
voltage, current, real power, apparent power and power factor The HEM hardware demonstration comprises a laptop computer that runs GUI software with the embedded HEM algorithm, four identical commercial off-the-shelf load controllers and four loads. This demonstration indicates that the proposed HEM system can monitor and control actual loads according to the designed DR algorithm. The measured electrical measurements of theloads confirm that the system performed satisfactorily during the entire experiment. The average communication time delay between the HEM unit and load controllers is in millisecond scale and increases slightly with communication distances. The residual energy of the proposed HEM system is estimated at 189 kWh per year. It is expected that this paper will provide an insight into the overall HEM system operation ,in particular providing a detailed look at the implementation of an HEM system for automated residential DR applications. The real-world implementation of the proposed system will benefit electric power distribution companies by helping to avoid distribution transformer overloads with the presence of new power intensive loads,like electric vehicles.

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