DESIGN OF INTERNET OF THINGS BASED SMART ENERGY METER USING EMBEDDED TECHNOLOGY AND ANDROID APPLICATION

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Abstract: Various energy management strategies includedistributed generation of electricity using renewable resources, distributed storage, effective control of smart appliances leading to energy conservation etc. The concepts like net zero energy buildings; roof top renewable generation and affordable storage schemes demand intelligent devices with net metering, appliance control and bi -directional communication capabilities. This paper, proposes a smart home controller which is capable of doing net metering, smart appliance control and bi -directional communication with utility and user. Smart Home Controller (SHC) is implemented using LPC2148 microcontroller, in which the net meter value is computed by offsetting the energy consumed from grid with the energy send back to the grid. RF communication module is interfaced to the controller so as to communicate with the room controllers for appliance control. Utility as well as consumers can access this device through GSM messages; providing consumer integration to grid. Our project to implement iot technology ,to connect and disconnect the power supply.

Keywords— Smart meter, Net meter, Appliance control, smart grid

1. INTRODUCTION

Conventional power grid finds it difficult to meet the electricity demand that increases disproportionately with the growth in generation. Mismatched supply and demand as well as absence of proper monitoring and automation has resulted in major blackouts in different parts of world [1]. In this scenario energy management has become a necessity to meet this supply-demand gap and provide quality delivery of electricity to consumers. This paves way for the concept of smart grid which is an integration of information technology and power grid. In smart grid, automation is adopted in power generation, transmission and distribution with the help of bidirectional communication achieved through Information and Communication Technologies (ICT) [2],[3]. Smart grid, among other features, facilitates different strategies for energy management. Distributed generation of electricity is an important strategy to reduce the energy crisis. It also involves generating electric power in small scale, by deploying renewable energy units at individual homes [4]. It reduces transmission loss, distribution loss and carbon emissions [4], [5]. Distributed generation (DG) makes the consumer also a producer (better known as prosumer) of electricity [6]. In smart grid, a 'prosumer' can supply excess of electricity generated to the grid enabling bidirectional power flow demanding net meter to calculate the net consumption of electricity from grid [7]. Net meter values can be sent to the utility using suitable communication technology.

Smart appliance control is another strategy that can be used for energy management in domestic sector. It optimizes the energy use by collecting the demand response signals from the utilities as well as the energy consumption status of home appliances, and then switching them ON/OFF as required [8].To implement this strategy, communication between utility control room and smart appliances at consumer premises is necessary. So there is a need of a device, at every consumer premise, which can act as a gateway for communication between the utility and the smart appliances [9].

Net meters and smart appliance controllers exist now as different entities [9]. Since both have a common functionality of communication with utility and user, these can be integrated into a single unit which minimizes the delay and reduces the interfacing errors. This paper presents a study that involves design and implementation of a net meter with device control capabilities, named as Smart Home Controller (SHC). SHC has the functions of both the net meter and the appliance controller and it is implemented using LPC2148 microcontroller. Net meter reading is computed by offsetting the energy consumed from the

grid with the energy returned to the grid. Since appliance control is integrated in SHC, communication between SHC and smart appliance needs a communication module. RF communication technology is chosen for this since it requires no change in the infrastructure. Both user and utility can access this device via messages through GSM/GPRS modem.

The next Section of this paper gives an account of past developments in this area. Section 3 presents the design and working of the proposed system while Section 4 discusses its implementation and the results and section 5 concludes the paper.

2. THE BACKGROUND

Smart meters with Advanced Meter Infrastructure (AMI) automatically collect the energy consumption data and send to utility [5]. The net meters started replacing the smart meters with the advent of distributed generation [10], [11] making AMI enabled net meter a reality. Such power injection to the grid is eligible for incentives [7]. Net meter counts forward when power from grid is consumed, and counts backward when power is sent to grid [7]. Control and management of electric loads is necessary for energy conservation so that demand for electricity can be reduced [12]. Smart homes have appliances enabled to communicate with smart controllers and users even from remote locations [13]. Besides AMI, applications like demand response, dynamic pricing, remote control of appliances, time of use pricing etc. needs bi-directional communication with utility. Utilities can make use of smart meters (SM) as a gateway to home appliances to realize this communication [5]. SM can communicate with the home area network in which all the loads are interconnected, so that energy use can be monitored and controlled. Thus the smart meter transforms into smart home controller that controls appliances based on demand response signals, also considering user priorities, helping to manage the power consumption [14]. Appliances status is communicated to utility too. There a gateway device which communicates between utility and the consumer premises is necessary [9], [15]. Smart meters based on GSM technology enable the two way communication with the utility as well as the user [16], in which the meter reading and the appliances status are sent to a central database of the utility where billing, troubleshooting and analysis are done [5], [17]. Utilities send the demand response signal and pricing signal to smart meters which facilitates the load management [18], [19]. Consumer interaction with smart meters helps to monitor the meter readings and billing information [17], [18]. The remote access of smart meter by consumers helps in consumer integration to the grid and considers consumer's wish also for energy management in consumer premises.

Provision of separate devices for metering and appliance control, when the two have a common functionality of communication with utility and user, cause difficulties in synchronization and so integration of these functionalities into a single device is considered. Researchers have suggested this integration in different ways. AMR-CTRL system proposed by Al-Ali et al. [9] is an embedded platform that integrates automatic energy meter with appliance control system. Power consumption in home is monitored and managed by the utilities with AMR-CTRL using SMS via public mobile network. Energy management scheme proposed by Meng Liu et al. [19] integrates the ideas of DG, energy storage and smart appliance control so that consumption of grid power can be minimized. Energy storage system stores the excess energy produced by DG and the grid absorbs energy once the battery is fully charged. A smart energy management system which gathers information on DG using power line communication and on consumption through Zigbee, controls the home appliances and stores the gathered information in a database that can be accessed through internet is discussed by Jinsoo Han et al. [15]. Erol Kantarci et al. [18] discusses the possibility of utilities communicating with smart meters about time of use (TOU) and smart home energy management systems controlling the appliances based on the received information .

Therefore a smart meter can be modified into smart home controller by integrating all the ideas discussed above and such a controller will be an optimal solution for energy management in consumer premises. So, this work proposes integrating the functionalities of net metering and smart appliance control into a single smart meter that is accessible through GSM/GPRS modem, for the utility as well as the consumer. The work targets to bring out a futuristic energy meter that integrates the advantages and overcomes the limitations in the existing systems of metering, appliance control, and consumer integration to grid at domestic level.

3. PROPOSED SYSTEM ARCHITECTURE

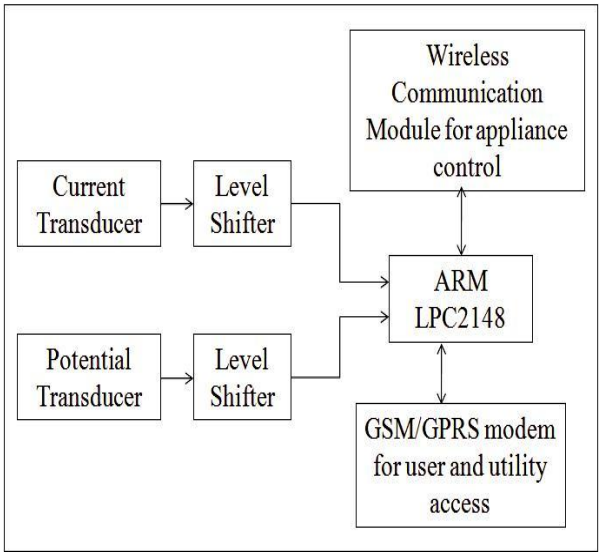

Figure 1: Smart Home Controller –the schematic

Schematic diagram of the proposed SHC is given in Figure 1. SHC consists of mainly three subsystems – net metering, appliance control and GSM/GPRS modem based user and utility access. Main module is an LPC2148 micro controller which integrates the software functions of the entire system. Net energy is calculated by the controller by taking level shifted inputs from current transducer and potential transducer. Demand response signals from utility are communicated through GSM messages to the controller to decide the action. These decisions are communicated to the appliances using wireless communication modems. User can also control and monitor the status of appliances from remote locations by accessing the SHC through GSM messages. The system architecture of a domestic energy management system with proposed SHC is shown in Figure 2.

The SHC, for net energy metering, computes the energy consumed from the electric power grid and that delivered to the grid from DG and calculates the net energy consumption. For appliance control, SHC has to receive input signals such as demand response signals, price signals etc. from utility based on which it communicates decisions through RF modems to the room controllers (RC) to control the loads. RF being a wireless communication technology, the infrastructure need not be changed. Since RCs are used instead of directly connecting loads to the SHC, flexibility is ensured by enabling addition and control of more appliances easily. RC based on the input from SHC turns ON/OFF the loads. SHC being accessible through GSM/GPRS modem, the loads can be controlled remotely by the user or the utility separately. Each home appliance will be given a specific id that the utility can specify to turn it ON/OFF.

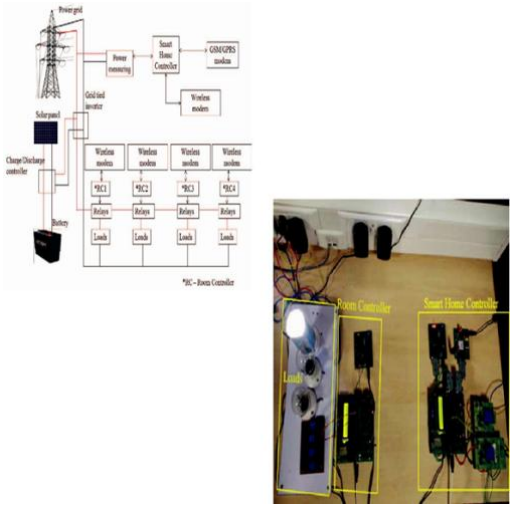

Figure 2: Domestic Energy Management System with proposed smart Home Controller.

Figure 3: Hardware Implementation of Smart Home Controller.

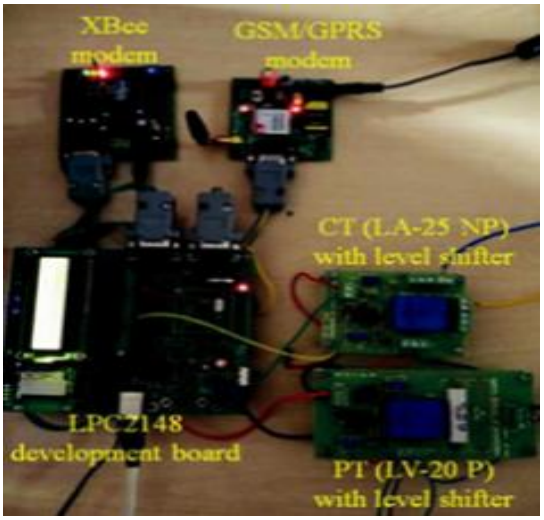

Figure 4: Experimental Setup.

Utility can send three types of messages: (i) requesting energymeterreading,(ii) sending ON/OFF command and(iii)sharing billing information;the user can send two types of messages: (i) requesting energy meter reading and (ii) sendinf ON/OFF command. Meter readings assorted as energy export, energy import and net consumption would be requiredby both utility and user.Both appliancesid and the ON or OFF command will be in the other cases.

SHC implemented usingLPC2148 microcontroller is shown in Figure 3. Net metering implementation needs two ADC Channels for simultaneous sampling of voltage and current. XBee module that uses Zigbee communication technology is selected for RF communication and is interfaced with LPC 2148 microcontroller. Two mobile phone numbers, one each for the utility and the user, are registered in the controller so that authenticityin SHC and the user/utility communication is ensured. Experimental setup consisting of SHC and one RC is shown in figure 4. The RC is connected to three lamp loads via relays and XBee module. Up on sending a command C1 ON from the registered user mobile phone SHC received it and passed the message on to RC using Zigbee, in turn the lamp with ID 1 Was turned ON.

Messages for different application are listed in Table

- These are classified into three – Request, Information and Command. The first character in the message indicates the class of message followed by the actual message. All the three types of reading (export, import and net consumption) belong to information class. Electricity bill is a periodic information message .ON/OFF instructions from both utility and user belongs to command class.

SCH is implemented usinf LPC 2148 and tested for different features. Response actions taken by SHC for different messages were tested are founded correct.

Message	Description	Source	Destination
REA	Request for all meter readings - import, export and net energy consumption	Utility/User	SHC
REE	Request for meter reading – energy export	Utility/User	SHC
REI	Request for meter reading – energy import	Utility/User	SHC
REN	Request for net energy meter reading	Utility/User	SHC
IEn	Exported energy: n units	SHC	Utility/User
IIn	Imported energy:n units	SHC	Utility/User
Inn	Net energy consumption: n units	SHC	Utility/User
IBn	Bill amount:n INR	Utility	SHC
CnON	Switch On the appliance having id as n	Utility/User	SHC

4. CONCLUSION

The smart home controller developed and presented here has a high commercial relevance globally. However, there are a few hurdles in its road map in the form of modularity, heterogeneity, performance requirements and development of standards especially for in-house communication. It is certain that the goal

of domestic consumer integration to smart grid will remain in focus of both academic research and industrial development. Then the required solutions in energy management at consumer level through integrated features of metering, appliance control and bi-directional user and utility communication also will become essential.

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