Design and Implementation of Power Consumption Visualization of Individual Appliances using Smart Meters

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Abstract

Electricity is one of the most important resources with invention of new appliances the consumption of electricity has substantially increased. Smart meter a new innovation assumed to bring change in power consumption and has been lacking behind. This paper presents a system in which metering and billing is automated and by using energy monitor. We show how and where power is consumed. Real time displays show power consumed by appliances. This feedback helps consumers in controlling power consumptions and thus hopefully consume less power. The energy monitors communicate with smart meter using NRF2401 and smart meter communicates to the server using GSM.

Keywords – smart meter, energy monitor, power consumption, energy conservation, feedback.

I. INTRODUCTION

Electricity is an important commodity. The consumption of electricity is only increasing. The generation of electricity from only renewable sources is most enough to satisfy our appetite. Therefore, we use a significant amount of fossil fuels to generate electricity and thereby learning a significant carbon footprint. Hence it has an adverse effect on our planets climate.

Smart meter is kind of meter that records consumption of energy at equal interval of an hour or less. It sends it to the server for monitoring and billing.

There are two types of smart metering systems. A system that uses only one-way communication is called automated meter reading(AMR) and a system which uses two-way communication is called advanced metering infrastructure(AMI) [1].

Studies haveshownthat timely consumption of energy can be reduced by providing users with real time feedback [2]. Smart meters make customers more energy conscious[3].

Socio techno surveys and research literatures show that real time feedback reduces or saves consumption of 5% to 15% [2]. Study is Stavanger, Norway shows 8% less electricity consumption by consumers who received informative bills, In Canada 6% reduction and in Denmark 22% reduction [4].

By adding energy monitors to smart metering, we can display real time consumption which in-turn helps customers to reduce consumption. Knowing how they consume energy plays an important role in influencing behaviour of the consumer[5].

Smart meter also saves huge labour cost in billing prosses. The resources needed to go and bill each household every month is eliminated. variable rate for power can also be implemented by using smart metering easily.

II. EXISTING MODEL

The existing model is very tedious costly and time consuming. Electromechanical meters are installed at each household the utility provides employee visit the household every month to take down reading and provide a bill to the household. Problems arise if weather conditions are not suitable or meter is inaccessible by the employee. This method involves huge labour cost also.

III. RELATED WORK

Several studies approached the problem of designing a smart meter. In paper [1] a digital KWH meter is need to generate a power meter readings. The readings sent to the server using SMS service of GSM. For testing they have used XBEE chip. For data management a visual basic program is used and consumer can use their power consumption in an android application.

In paper [6] we have an GAPMR system where an IFC61036 standard compliant digital KWH power meter in used with a GSM modem. Communication between smart meter and server is done using SMS service and GSM. The costumers are billed using a e-billing system and alerts are sent through SMS.

In paper [7] meter readings are generated based on LED meter pulses. It uses GPRS to connect to the server.

In paper [8] an Actrias meter is used to generate power reading, these are served to the sever using SMS service of GSM. They have developed an NRI-ACDCS software using Microsoft SQL and Microsoft .net to receive, organize and view data.

In paper [9] again LED meter pulses are used to generate readings, then send readings to a central node using RF module and then similar readings from other meters are collected at node and sent to server using GSM.

In paper [10] current transformers are used to detect current and potential transformer are used to detect voltage, power readings are transmitted using GSM. Software used to monitor and control is used and written in visual basic. The system uses a 32-bit ARM processor. If even has a relay to disconnect consumer's power supply via control software.

IV. PROBLEM STATEMENT

The tedious job of going to each and every household and bill them is to be eliminated and providing feedback to consumers to help them in reducing power consumption should be incorporated. Energy monitors attached to appliances to provide feedback and GSM network are used to communicate meter readings to the server for billing purposes.

V. PROPOSED SYSTEM

The Proposed system has mainly two section.

A. Home power recording system.
B. Utility server.

A. Home power recording system.

The home power recording system consists of two sub system.

i. smart meter.
ii. energy monitors.

i. Smart meters

Smart meters are used to record the power consumption of the active household. And send the recorded power readings for billing and monitoring. The smart meters used to detect the voltage and current consumption to find the power consumption. The voltage is detected by using a 12V AC to AC step down transformer, then a bridge rectifier is used to convert AC to DC. A voltage divider is used to get the detected voltage to 0-5V DC range. Current is detected using a current transformer, it produces a voltage for the amount of the current running in the phase wire, the voltages are detected by Arduino micro controller. Nordic radios such as nRF2401 is used and a mesh network is setup for communication with energy monitors. A SIM900A module is used to connect to the server. This uses the GPRS/EDGE network of GSM to connect to servers. The Arduino take all reading and call a PHP script at the server using HTTP protocol to insert the values into the database.

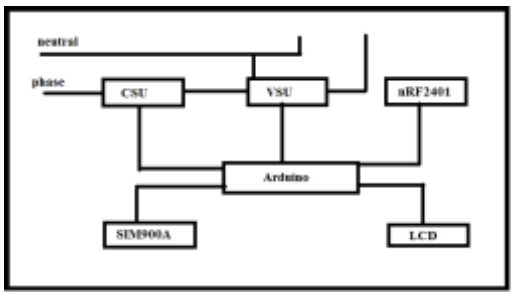

Fig 1: Design of smart meter

An LCD is used to display real time results of the power consumption. This also shows the next of the power consumed in currency (for India in Rupees).

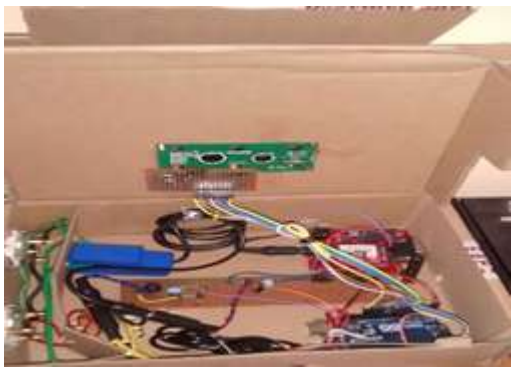

Fig 2: Model of smart meter

ii. Energy Monitor

The energy monitor has the same structure such as the smart meter. But dos not have the GSM module. These connect to the mesh network setup by the smart meter. This shows the real time consumption of power for appliances. Note: For testing purpose we have used two rooms of the house instead of appliances. It shows the power consumed by the rooms of the house.

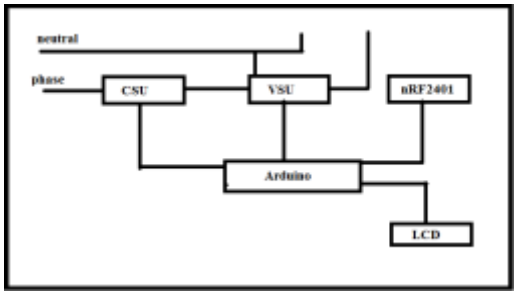

Fig 3: Design of energy monitor

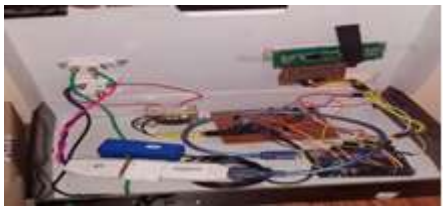

Fig 4: Model of energy monitor

B. Utility Server.

This has database to store all the readings concerned to power consumption and details about the consumers. These details can be changed by the administrator.

Fig 5: Screenshot of Admin login page

Fig 6: Screenshot of Customer database

It also provides a web service to consumers where they can login and view their power consumption details. The detailed power consumption graph and pie charts or provided here.

Fig 7: Screenshot of Customer login page

Fig 8: Screenshot of Customer's bill details

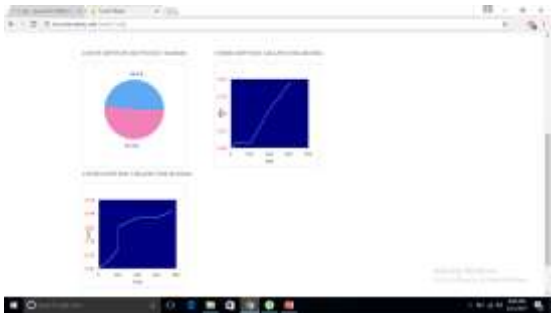

Fig 9: Screenshot of power usage graph

Bills are forwarded using E-mail and SMS. E-mails are sent using Google's g-mail server and PHP mailer library.

Fig 10: Screenshot of mail received by customer

SMS are sent using way2sms.com SMS gateway.

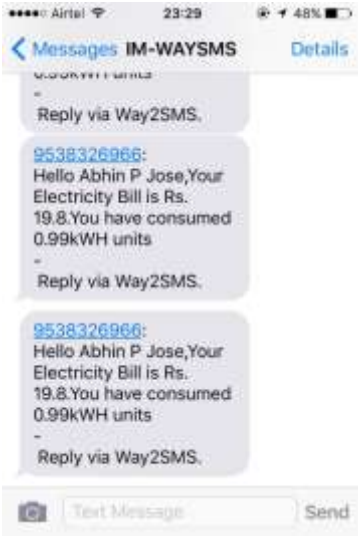

Fig 11: Screenshot of SMS received by customer

VI. CONCLUSION

The system can only show how much and where electricity is consumed. It cannot directly reduce power consumption. These real time feedbacks encourage the consumers to consume less power and cut cost. These feedback instrument are only useful only ifconsumer's routine is properly integrated to the instruments to reduce the consumption. The smart meter technology helps to reducing costs, it avoids human intervention and error, reduces use of more power. The system is totally automated as the bill can be cleard only. The initial investments of setting up a smart metering system may out do the cost of maintaining the traditional system in the long run.

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