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Live Energy Meter Reading and Billing System through GPRS

Dinesh Prasanth M K[1]
Department of Information Technology,
Kongu Engineering College, Perundurai, Erode – 638052
Tamil Nadu, India

***Abstract*—The current electric meter doesn't have provision to monitor our electricity consumption. Also, the provision for generating bills automatically is limited and inefficient. Until now, Automatic Meter Reading (AMR) system uses SMS as the medium to transfer data to the server. But, the designed energy meter uploads the reading periodically to a central public server through GPRS. GPRS is more cost effective than SMS and is very useful in frequent update. There is no need for a person to visit every home at the end of every month for checking the reading. The bills are generated automatically at the start of every month. In recent years, the number of smart phone users have increased drastically. The users can view their current Energy meter reading and also pay their Electric bills through mobile application. The users can also monitor their Energy meter on-line and they are also given an option of paying the bill on-line. By using this system, the users will be aware of the electricity usage in his/her home. With slight modifications to the system, it can be used by corporate companies to monitor their power consumption and help them reduce the power wastage to a greater scale.**

***Keywords*—GPRS, GSM, Energy meter, Android, Billing automation, Web Portal, ARM**

I. INTRODUCTION

Internet services and mobiles have become an inextricable part of daily life, enabling communication and the management of personal information from anywhere and at any time. Recently, there has been several issues of faulty energy meter and theft of electricity. Till date, the readings are manually collected at the end of the month by a person from EB department by visiting every home. Also, the user needs to pay the electric bills either through on-line or by visiting EB offices. We have designed an energy meter to ease the work of both users as well as EB officers.

The proposed system provides graphical user interface for monitoring the energy meter through web portals and also through Android mobiles. All Android operating system mobile phones can use this application. The Automatic Meter Reading system consists of client-server architecture where the web browser is the client and the server functions are shared between a web-server, a communication server and a database server.

The reading is automatically sent to the server along with the service number of that particular meter. This information is used by the server to calculate the total consumption of electricity of the end user and generates the Electricity Bill automatically at the end of every month. All these information can be viewed through web portal or an Android mobile connected to the internet.

II. EXISTING SYSTEMS AND RELATED WORKS

A. Simple energy meter

A simple energy meter measures electricity consumption of an end-user. The most common type is a kilowatt hour (kWh) meter. When used in electricity retailing, the utilities record the values measured by these meters to generate an invoice for the electricity. They may also record other variables including the time when the electricity was used. Modern electricity meters operate by continuously measuring the instantaneous voltage (volts) and current (amperes) and finding the product of these to give instantaneous electrical power (watts) which is then integrated against time to give energy used (joules, kilowatt-hours etc.). The meters fall into two basic categories,

1. Electromechanical and electronic.
2. Electromechanical meters

Fig. 1. Energy Meter

The most common type of electricity meter is the Thomson or electromechanical induction watt-hour meter, invented by Elihu Thomson in 1888.

B. Existing Automatic Meter Reading systems

Many systems built on various platforms have been proposed by different research groups all over the world for AMR. There are two types of AMR systems, wire-based and wireless. One such system is uploading the data through SMS to the server. Only the total electricity consumption can be calculated in such systems. In advanced systems, the reading values can be monitored. But, it requires designing a separate device and setting up additional hardware which makes it costly to be implemented. Some communication mediums used are Zig Bee, Narrow B & RF and Power Line Communication (PLC). Each of the medium has its own complexities and cost factors

C. Disadvantages of Existing AMRs

SMS is costlier and sometimes unreliable. Other advanced techniques are costlier to implement and are more complex. Also, there is no protection from tampering of energy meters. In most cases, the errors in the system can be identified only at the end of the month

III. PROPOSED SYSTEM

Since GPRS is cost effective compared to SMS, monitoring of energy meters at lower cost is made possible. Daily consumption reports are generated which can be monitored through Android application and/or web portal. Also, android users can pay their electric bills from their android application. Non-android users can monitor and pay their bills online. The system is more reliable and accurate reading values are collected from energy meters. Live readings of the energy meter can be viewed through Android application. Also, the readings can be viewed online. The human intensive work is avoided and all the values are maintained in the central server. The communication medium is secure and tampering of energy meters can be identified easily. If an error occurs in the system, the value in the central server will not be updated. Once the value updated crosses the threshold time, the server can determine that something is wrong in the system and can report the engineers in EB. Thus, identification of error becomes easier. Since the values are stored in the central database, the reports are made accessible from anywhere in the world. Also, the server is online 24x7.

A. Advantages of the Proposed System

The users can be aware of their electricity consumption. The human work of collecting readings by visiting every home at the end of every month can be avoided by generating Electricity bills automatically. Theft of electricity can be avoided by tamper proof energy meters. The errors in the system can be identified quickly.

IV. SYSTEM DESIGN

The designed energy meter includes a simple energy meter, a GSM modem (SIM-900), A PIC 18F4550 (master controller), 8051 microcontroller (measure electric pulse), web portal with database and android app installed in user's mobile. The system can be divided into 3 parts: The project is mainly divided into 3 modules: (a) Hardware design (b) Mobile interface design (c) Server design

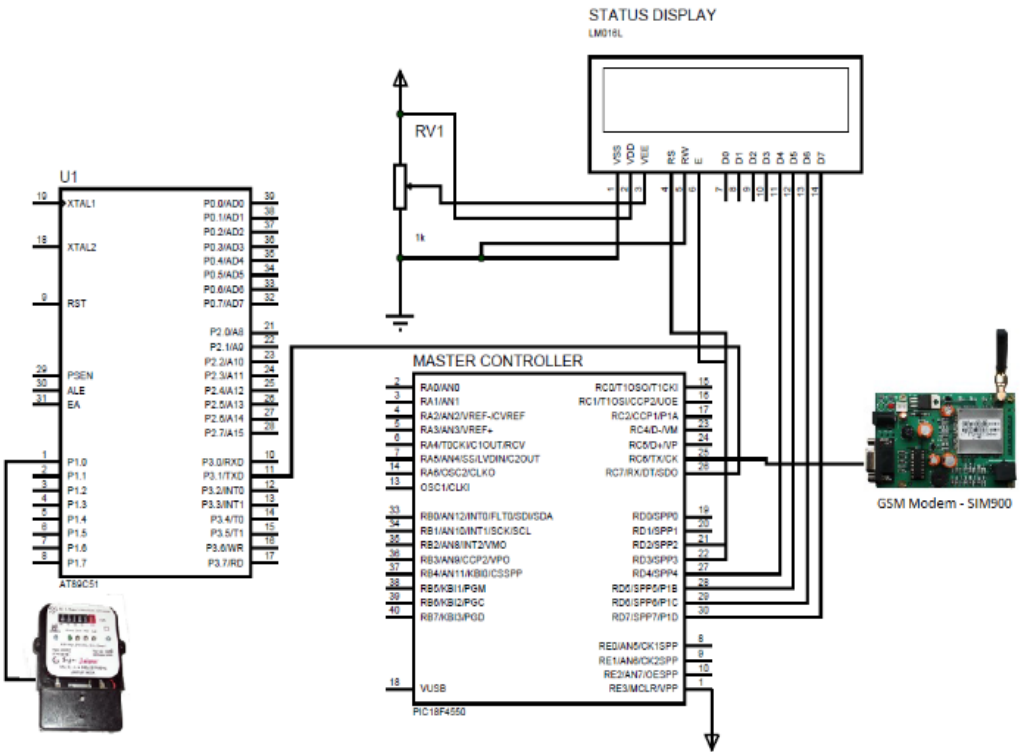

Fig. 2. Detailed Circuit of Energy Meter

A. *Hardware Design*

General Packet Radio Service (GPRS) is the main method of communication between the energy meter and the web server. GPRS, being a 2.5G mobile technology, is available all over the world. It is also ideally suitable for data transfer over an always on-line connection between a central location and mobile devices. The cost is per kilobyte of data transferred, in comparison to SMS where the cost is per message. The reading information from the energy meter in real time is uploaded to a central database via GPRS. Each user of the system may access this information via the Internet.

8051 microcontroller is interfaced with energy meter and PIC 18F4550 which acts as the master controller through RS-232. The PIC is interfaced with GSM SIM-900 module which is connected using RS-232. The receive pin of RS-232 of PIC is connected to the transmit pin of RS-232 of 8051. The transmit pin of RS-232 of PIC is connected to the receive pin of RS-232 of SIM900 module.

8051 microcontroller monitors every pulse of the energy meter. It sends the measured reading to PIC 18F4550 every time the value is changed. PIC 18F4550 gets the reading from 8051 and then communicates with SIM900 through AT commands and transmits the reading information through GPRS to the central server.

B. *Mobile Interface Design*

The application starts to work when the user accesses its services by clicking the application icon on the screen. After the application starts it waits for the user response to enter the credentials to access this account. Once the user enters his credentials and clicks the Login button, the application verifies the user info stored in the central database. After authorization, the user gains access to his Dashboard. The Dashboard contains all the details about the user's electric meter. It displays the current day's consumption, current reading, yesterday's reading, and last updated time. The user can choose the Billing menu to view the current billing information. It displays the start date & end date of the bill, Billing date, total consumed units, total amount to be paid and bill status.

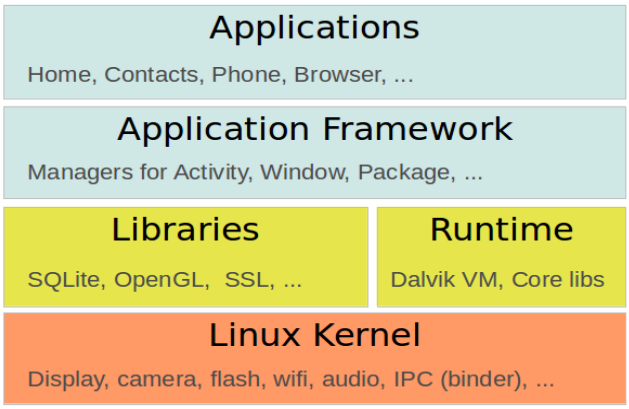

Fig.3. Android Simple Architecture

The application sends and receive data through HTTP POST method. Since internet is used, the Android mobile needs to be connected to the GPRS network. The only disadvantage is that when an android device is connected to the internet, it drains the battery at a faster rate. But, with recent updates of the Android version and the recently introduced long lasting batteries, increase the operating time of the mobile handset.

C. *Server Side Design*

The server uses the PHP scripts to receive the data, process and store it in the central database.

Formulae:

To calculate live reading:
Live reading = last day's reading in server + current reading from meter

To calculate total units consumed at the end of month:
Current reading = Last day's reading in server + current reading from meter
Total units = Current Reading – last month end reading

The reading from the meter is received by the server. PHP script reads the information using GET method. Based on the time and date, the reading is categorized whether the received data is current day's reading, next day's reading or next month's reading.

If the reading is for the same day, the current reading value is updated. If the reading if for the next day, the readings are updated accordingly. If the reading is for the new month, then a bill is generated.

All the values received and processed are stored in the MySQL database. There is no more conversion required on retrieval as the processing is done before inserting into database. The values are directly retrieved by the web portal and the android application. The users can view these information in either way.

V. SYSTEM IMPLEMENTATION

A. *Software Flow*

The pulse for every unit from the energy meter is monitored

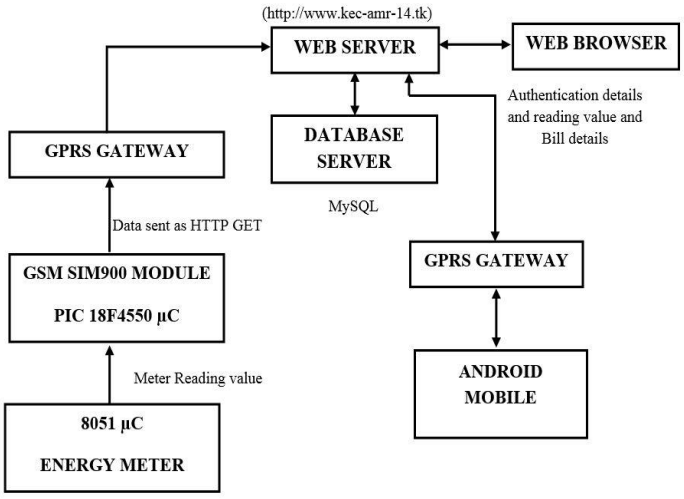

Fig.4. Data Flow Architecture of Proposed System

using 8051 microcontroller. This monitored value is sent to the PIC controller which acts as the Master. For every 30 seconds, the PIC controller tries to send the value received to the central public server through GPRS using GSM Modem

B. *Monitoring Server*

Monitoring server collects all information received from the energy meter units installed in every home and stores it in a central database. It is accessible to end-users through web-portal/mobile app. End-users can monitor their energy consumption and view their bills. Monitoring server actively monitors for the data from the energy meter and records the information received in the database. It also monitors the time

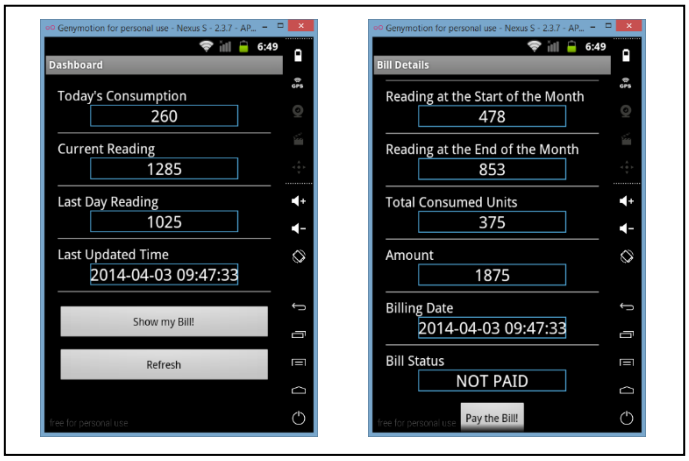

Fig. 5. Android App with all the details

of the data received and adds a time stamp to the data. Data is processed according to the time stamp. Bill generation is done automatically by this server at the end of every month without any manual work involved.

VI. System Security

System security refers to various validations on data in form of checks and controls to avoid the system from failing. It is always important to ensure that only valid data is entered and only valid operations are performed on the system. The system employees two types of checks and controls. Also, the system must be tamper proof and detect any electricity theft.

A. *Client Side Validation*

Various client side validations are used to ensure on the client side that only valid data is entered. Client side validation saves server time and load to handle invalid data. Some checks imposed are: (1) JavaScript in used to ensure those required fields are filled with suitable data only. Maximum lengths of the fields of the forms are appropriately defined. (2) Forms cannot be submitted without filling up the mandatory data so that manual mistakes of submitting empty fields that are mandatory can be sorted out at the client side to save the server time and load. (3) Once the bill is paid successfully, "Pay my bill" button is hidden so that the users don't get confused and accidentally repay the previous bill.

B. *Server Side Validation*

Some checks cannot be applied at client side. Server side checks are necessary to save the system from failing and intimating the user that some invalid operation has been performed or the performed operation is restricted. Some of the server side checks imposed are: (1) User is intimating through appropriate messages about the successful operations or exceptions occurring at server side. (2) Various Access Control Mechanisms have been built so that one user may not agitate upon another. Access permissions to various types of users are controlled according to the organizational structure. Only permitted users can log on to the system and can have access according to their category. User- name, passwords and permissions are controlled on the server side. (3) Using server side validation, only the values can be retrieved by the web portal and android application. This avoids the change of reading or billing amount details from unauthorized personnel. (4) The server accepts data only from the Energy meter and only the server can be able to modify or insert values in the database

C. *Hardware Side Validation*

The designed energy meter has its own unique identification number. The data in the server is updated according to this ID. If any user tries to steal electricity, there will be discrepancies in the data stored. Since the monitoring server is active 24x7, it can detect the variance and report the issue to the EB engineers.

VII. Conclusion

Live Electric Meter Reading and Billing system is successfully implemented using existing Electronic Energy Meters where GPRS is used as the communication medium to get the values of the meter. The earlier versions had used SMS as the communication medium; however the current implementation uses GPRS which reduces the cost of communication and enables frequent updates of the readings. The proposed system avoids electricity theft to a large extent and also makes the energy meter tamper proof. This system also helps the users to be aware of their energy consumption. The information is transmitted to the EB server using GSM/GPRS modem on GSM network using direct TCP/IP connection with EB server through GPRS. EB server uses PHP scripts to get the values from the energy meter and stores this information in database. This information is available to authorized users of the system via website over the internet or using mobile application.

Future Works

Future works include dynamically getting values from energy meter whenever the user sends a request to the server with minimum constrain of updating the values in the server at least once a day. A widget for the mobile users can be created to help the users to be more aware of their electricity consumption. Also, the bill information can be sent as push notification to smart phone users; for general users the

information can be sent as SMS. Everyday consumption along with graph can be constructed for more convenient understanding of the consumption by the users. The bills generated can be mailed automatically to the corresponding user's E-Mail ID whenever the bill has been generated by the server. An alert system at the server can be set up to check whether the system has failed or the energy meter has been tampered. An algorithm can be implemented in the server for monitoring the energy consumption of the user. This way, if user steals electricity, the server will notify the EB engineers. This system can be modified slightly and can be used in corporates to monitor their energy consumption in different parts of the building. This way, they can conserve electricity wastage to a greater extent.

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