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An Intelligent and Wireless Based Home Area Networks for Metering In Smart Grid

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Abstract: ***Smart grid is a modernized energy networks that can monitor energy flows intelligently and adjust to changes with respect to energy changes and demand. The traditional electric grid was built earlier and improved upon as technology through each decade. The ability to communicate seamlessly across multiple networks and domains is an open issue which is yet to be adequately addressed in smart grid architectures. In this paper, we present a possibility for end-to-end interoperability in home and building area networks within smart grids. The Automated Metering Infrastructure (AMI) concept allows a utility to install a smart meter in every customer premise that can communicate with appliances and devices and control their operation and overcome the errors which occur in traditional metering system. An experimental prototype of the AMR was designed to demonstrate the effectiveness and efficiency of automatic meter reading, billing and notification through GSM network.***
Keywords: Automated meter reading, Global system for Mobile communication, Real Time clock

I. INTRODUCTION

The scope of smart grid extends over all the interconnected electric power systems, from centralized bulk generation to distributed generation (DG), from utility control centers to end-user home-area networks, from bulk power markets to demand response service providers, and from traditional energy resources to distributed and renewable generation and storage. A smart grid is a modernization of the legacy electricity network. It monitors, protects and optimizes automatically the operation of interconnected elements and their functions. The smart meter has the ability to control as many appliances/devices operate at a given time connected to it and thus it helps to achieve load balancing during peak demand period. The smart grid control center looks at aggregated load from all its customers at a given time and can issue specific control instructions to the smart meter in a customer premise. Demand response services can be enable with help of Information and Communication Technology (ICT) that can respond with pricing signal and reports about grid condition. It encourages consumers to use energy efficiently to reduce peak load in demand hours through smart grid enabled energy management, which results in financial savings for both consumers and electric utilities. On the other hand customer benefits by having his/her appliances operate at times of lower demand, which typically have lower electricity rates, thus saving economy. Without the AMI infrastructure, the customer would have to keep track of off peak times and rates, which would prove cumbersome. Various AMR methods and technologies were already in use such as power line carrier (PLC) communications, (SCADA) Supervisory Control and Data Acquisition, telephone modem, Internet, Ethernet, Embedded RF module, Wi-Fi, Bluetooth and ZigBee were established and developed to demonstrate the solution of efficiency, reliability and effectiveness of AMR. With the rapid development of GSM infrastructure and Information Communication Technology in the past few decades has made the wireless automatic meter reading system more reliable.

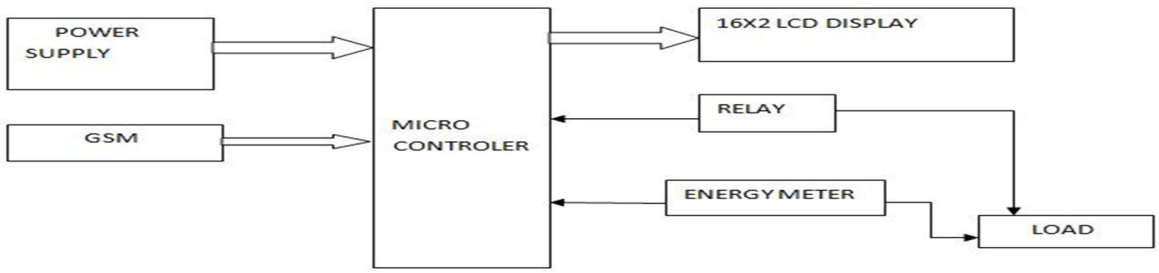

Figure 1.1: Smart Meter Architecture

The objectives of the project involves

A. Remote Monitoring and control.
B. Reduced Man power.
C. Tempering alert feature.
D. Auto connect/disconnect feature.
E. Power cut information feature.

II. LITERATURE SURVEY

According to [1], In order to obtain full benefit of smart grids, their communication must support device control and data exchanges between various domains which comprise the smart grid. Home area network facilitate the interconnection of smart appliances with smart meters to automatically regulate residential electricity usage and response to pricing signals from the utility, the smart grid must facilitate services including the wide scale integration of renewable energy sources (solar,windmill,battery) provision of real time provisioning to consumers and earlier power outage detection. These tasks demand the collection and analysis of real time data. According to [2], Automatic Meter Reading (AMR) technologies, electrical utilities (EUs) have been exploiting their own infrastructure to bill their customers in concern with efficient and economy. AMR applications have been demanding low bit rates since the amount of data that has to be send is quite low related to the available time to perform this task. At this moment, EUs also exploring and demanding other services as load management, remote monitoring and connections/disconnections of relay etc. Low Voltage modems should provide high throughput while keeping the cost of the hardware low. It tracks the meter reading everyday with user identification number. Thus there will be no confusion for the user while paying the electricity utilization. The results of the power-flow studies are compared to those determined using the actual customer meter readings.

Daily kWh
Monthly kWh

According to [3], the top trends in smart grid which tend to focus on the utility side of the meter and some do not involve end use customers at all. Distribution automation is really an umbrella term, along with the distribution, some of which have been in use for many years. The main purpose is to make power distribution networks more reliable and efficient by introducing a high degree of automation and autonomy to the system.
According to [4], Automatic meter reading system based on Microprocessor is implemented which provides a cost-effective, authentic and intervention free data transfer between the utility control centre and remote meter reading units. By this way, human involvement is not needed in meter reading and management processes. Based on the existing communication technologies and telephone networks, it is very easy for the utility companies to maintain, service and to access meter reading system.
According to [5], the energy meter which generates the pulses as well as count the energy consumed. The digital energy meter is having a LED which blinks for a specific number of times to indicate the energy consumed (e .g. 1 Unit = 1600 pulses). These pulses are fed to ARM based system which is programmed to count these pulses. The system reads and counts these pulses which then increments the internal counter by one which indicates the number of units consumed.
According to [6], a GSM based wireless communication module is computed with energy meter of every entity to have remote access over the electricity usage. A PC with a GSM receiver database acts as billing point at the other end. Live meter reading consumed from the GSM enabled energy meter is sent back to this receiver database periodically and these details are updated in a centralized manner. More reliably, users from anywhere in the world can access the developed web page details. After processing this data the entire monthly usage and due date is informed through mail to the customer. So GSM based wireless AMR system is more efficient when compared with convention at billing system. This system also allows the electricity companies to take actions against indulgent customers, who have outstanding dues, or else they have rights to disconnect the power supply and also it can reconnect power supply after payment of dues.

III. EXPERIMENTAL SETUP

Figure 3.1 shows the AMI concept that allows a utility to install smart meter in every customer premise that can communicate with appliances and control their operation and then sent to server. With the introduction of AMI technology, a two-way communication between a “smart” meter and the control center as well as the meter and residential power equipment would be facilitated for

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demand response, dynamic pricing, and system monitoring. For data collection the meter can read through a serial port (e.g., RS232), Radio Frequency. Smart meters enjoy high hardware/software capabilities that enable them to run TCP/IP suite and have the ability to run applications on top of TCP. Smart meters are equipped with processing capability ranging from SOC (system on a chip) microcontrollers to 32-bit processors. The program supporting an extensive library of routines and applications that has a specific task of scheduling that rotates between a number of tasks such as communication, activity and database management.

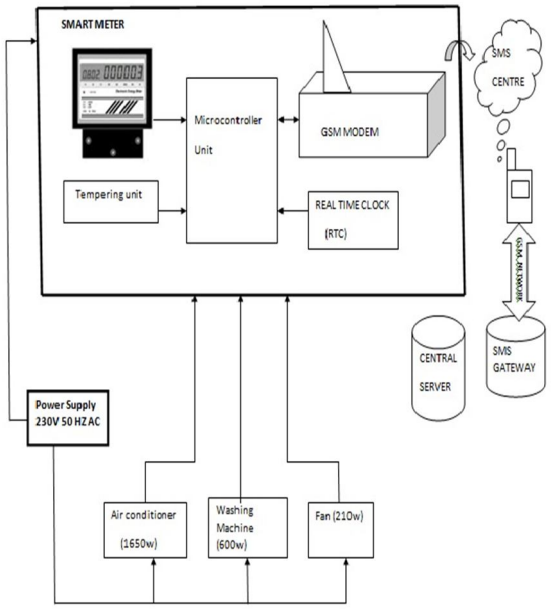

Figure 3.1: Smart meter setup

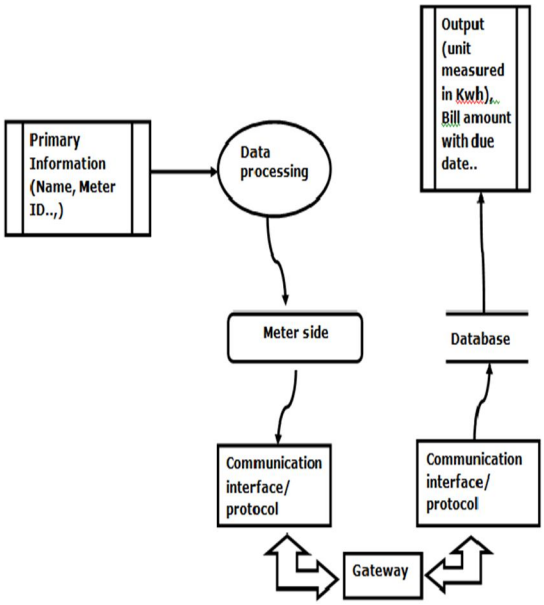

Figure 3.2: Operational procedure

The figure 3.2 shows the operational procedure for the meter side for the measurement of meter reading from the remote location. The message which is in the form of AT commands sent by the server side for the request of the reading. When the power supply is given, IC in the meter create the output in the form of pulses which will be counted by the timer present in AT89S52 Microcontroller, to read the data from meter and the operations such as scheduling the date to receive the data consumption of every month, the AT89S52 is programmed using keil c software. Power connects and disconnects features were being programmed and interfaced to hardware. A 16x2 LCD display is used to display the reading and also indicates the transmission and receiving of messages. A Real Time Clock is used to update the time information. EEPROM is used to store the data. If there is any lenient customer who doesn't pay the bill, a message send from the server side to control the power which is received by the GSM modem, the microcontroller reads the message from the SIM and initiate the RELAY which is used for ON and OFF the power according to the data of the message.

IV. RESULTS AND DISCUSSION

The below figure 4.1 shows the setup of GSM based energy meter which is interfaced with Microcontroller and GSM module. Based on the power utilization by the customer the power consumption pulse will get incremented and on reading the 1600 pulse, a unit will be incremented by the counter continuously. To initialize GSM modem a SIM card is fixed to the module. As per program schedule, the data will send to database for once in every month. The output will be displayed as shown below and it includes the details of unit consumed and amount for those units and due date to pay the amount. Customer can use the online portal to pay the bill upon receiving the notifications to pay the due amount.

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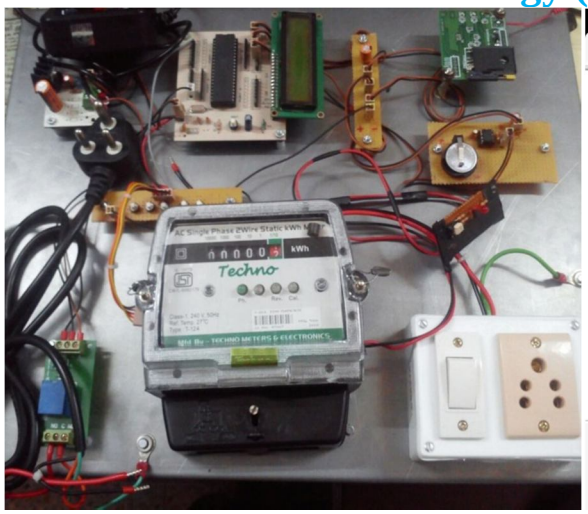

Figure 4.1: Prototype Model

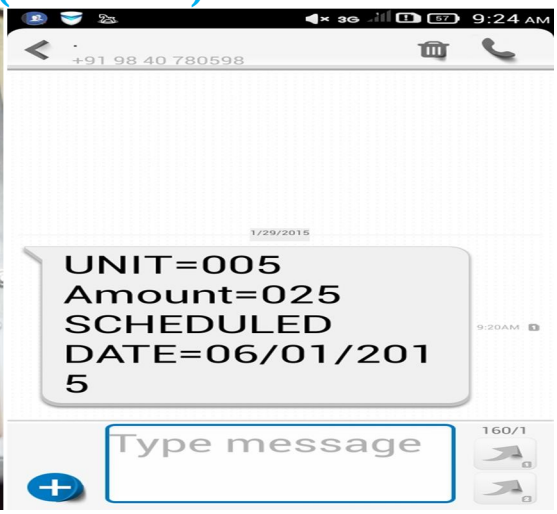

Figure 4.2 Output shown in Mobile

If there is any lenient customer who does not pay the bill then from server side (i.e from utility center) they will send a Command to the SIM number to cut the power supply which is present in the GSM module. After receiving the sms, the request is being sent to Microcontroller to cut the relay by disconnecting the power flow.

If the customer pays the bill then again a request is sent to Microcontroller to enable the power flow which is shown below.

Figure 4.3: Commands to disconnect power

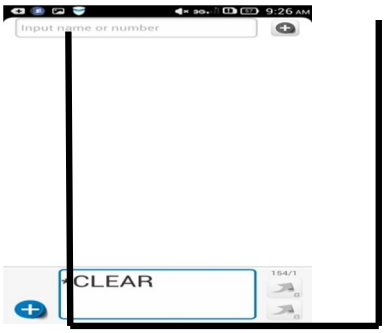

Figure 4.4: Commands to enable the power

V. CONCLUSIONS AND FUTURE WORK

GSM based AMR have cost-effective infrastructure with low operating costs providing more data security and less man power requirement. In addition of solving the problem of manual meter reading it also provide additional features such as power connect, power disconnect, power cut alert and tempering alert. Customer can also use the existing methods to pay bill via online login on authenticated web. Data base server can store the current month data and also for future use it stores all previous month. In future, Demand response is used for energy based tariff which is a key feature of smart grid. The addition of bidirectional communication to today's power grid can provide real-time pricing (RTP) to customers via smart meters. To propose an scheduling scheme based on the optimal stopping rule as a real-time distributed scheduling algorithm for smart appliances to determine the best time for appliances operation to balance electricity bill reduction and inconvenience resulting from the operation delay.

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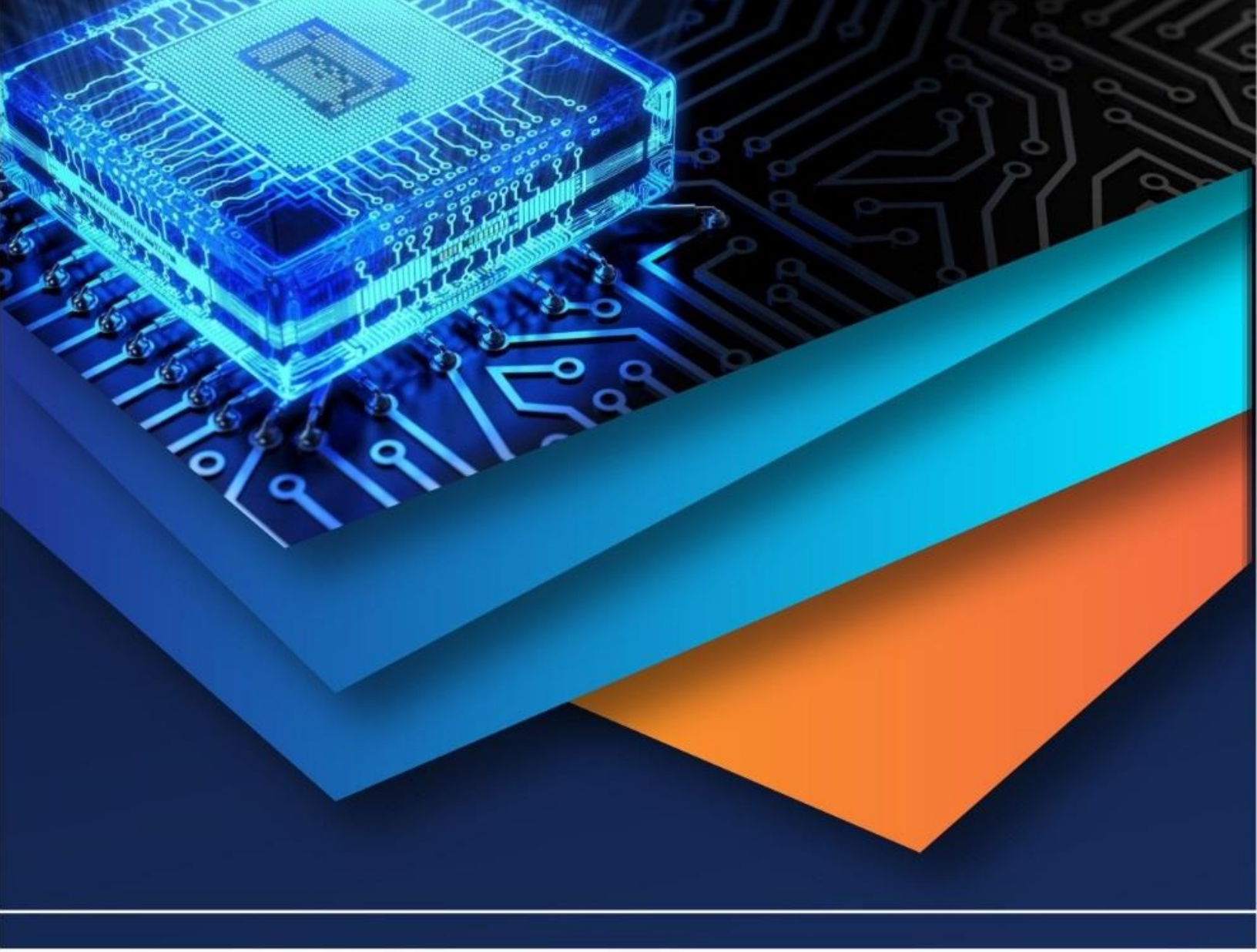

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