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Smart Energy Meter Using IoT

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***Abstract*: Electricity plays a vital role in day to day life. Today keeping track of electricity consumption is a tedious task. Because one has to go for meter reading room to take down readings. The main problem of this system is that person has to go area by area and he has to read the meter of every house and handover the bills. Sometimes errors may occur such as extra bill amount, or notification from electric board even though the bills are paid. To overcome these problems the system can be automated by allowing users to monitor energy meter readings over the internet. In this paper the idea of smart energy meter using IoT and NodeMCU have been introduced. In this system NodeMCU is used because it is energy efficient i.e. it consumes less power, it is fastest. And a GSM module is used in this system for sending SMS to the user. As a whole this system is proposed to demonstrate its capability to check the current usage, sending message when reaching the limit, reset the limits through accessing GSM based mobile phone.**

***Keywords*: GSM module, NodeMCU.**

1. Introduction

Most of the daily activities such as education, shopping, banking requires electricity as a very important factor. Electricity will be used for lighting, heating, cooling and for operating appliances. A significant amount of the total electricity produced globally is used for household purposes. It is necessary to use the electricity in an efficient way because it allows people, governments and businesses to save money, and it lets power plants avoid costly upgrades.

Various technologies have been developed and used to measure the electrical consumptions. In the present billing system, at the end of the month a person from the meter board billing will visit every house to read the meter reading and at the same time, give the bill to the users. An electricity meter or energy meter is a device that measures the amount of electric energy consumed to residence or business. In the existing system it is difficult to keep track of changing maximum demand of consumers. And also there some problems associated with this system like due bills for bills that have already been paid or poor reliability of electricity supply and quality even if bills are paid regularly or the consumer may not be able to know about the usage of electricity on daily basis. So, it is important to find a solution to overcome these problems. This paper mainly focuses on the system that helps to solve the problems of existing system. Internet of Things (IoT) is an emerging field and IoT based devices have created a revolution in electronics and IT. The very important objective of this system is that to create awareness about energy consumption which helps in efficient use of home appliances for energy savings. This smart system will provide the information about meter readings, the cost according to the meter readings and it gives alert message when the set limit is exceeded. This idea can reduce the human dependency to collect meter readings and bills. And the consumers can keep track of energy consumption.

This paper proposes a new network communication system for energy meter reading by internet communication technology and software system along with the existing meters. An IoT modem will be integrated with an electronic energy meter to read the usage of electricity and uploaded on a server or website. Energy meters deliver the reading details and it is uploaded on the website instantly. This communication system is further useful for electricity regional/sub-regional office, who can monitor the value and power consumption. And they cut the power supply for any specific house, who had not paid the electric bill. Here each customer is differentiated using address or Id, this ID are used for identification by the consumer and as well as by office to monitor the reading and payment detail. It is secured by any network standards. Energy meter deliver the reading details and it is uploaded on the website instantly. Moreover, this power cut control system is done by using same website which is used for monitoring. In this project each customer is differentiated using address or Id, this ID are used for identification by the consumer and as well as by office to monitor the reading and payment detail.

Electricity is one of the vital requirements for sustainment of the contents of life. It should be used very judiciously for its proper utilization. But in our country we have a lot of locality where we have surplus supply for the electricity while many areas do not even have access to it. Our policies of its distribution are also partially responsible for this because we are still not able to correctly estimate our exact requirement and still power theft is prevailing. On the other hand, consumers are also not satisfied with the services of power companies. Most of the time they have complaints regarding statistical errors in the monthly bills. With this we can monitor the meter and track

if any fault is there or not. In the previous meter a circular metal strip rotates and according to that rotation we calculate the consumption.

This system is the combination hardware and software. The main component used in this system is Arduino which continuously monitor and records the energy meter readings. These readings will be displayed on the designed web page on the request. Other components that are used in this system mainly include GSM and Wi-Fi modems to introduce the 'smart' concept. The use of GSM module helps to send the SMS. The advantage of this system is that a user can understand the power consumed by the electrical appliances on the daily basis and can take further steps to control them and thus help in energy conservation.

2. Literature Survey

The advancement of the Internet of Things has been emerging day by day. The Internet of Things (IoT) revolves between M2M that is embedded with electronics, software, sensors, actuators that assist users in monitoring and controlling devices remotely and efficiently [1]. In the IOT based system object and living being are provided with unique identifiers with the ability to transfer data [2]. The area of IOT has amplified from the convergence of wireless technologies, micro electromechanical systems and the Internet [2]. Nowadays IOT technology is being applied in many areas like electricity, gas, water etc. to make our life automated. Nowadays due to the excessive use of the internet, these areas become computerized and an online payment system makes possible. But accessing meter reading is a manual process and has the possibility of error which causes high revenue cost [3]. Automatic Meter Reading (ARM) technology facilitates the assessment of energy consumption and analysis of data for billing and payment. ARM technology requires bringing the device online and connecting the device with the internet which is in other terms Internet of Things [1]. ARM technology using wireless communication is cheaper than wired medium. Hence,

Wi-Fi is more suitable for the proposed system as it is very common in every residence. According to statistics, the number of smart phone users in the world was 2.87 billion in 2017 [4].

The percentage of Android phone users in Bangladesh was 79.21% in December 2017 [5]. These statistics indicates usage of Android phones in the country. Hence, we choose the Android platform to implement our system. The total amount of installed electricity generation capacity (including captive power) in Bangladesh is 15,351 megawatts (MW) estimated in January 2017. In 2015, 92% of the urban population and 67% of the rural population have access to the facility of electricity [6]. People have to check their electricity meter reading manually. In Bangladesh, there are some people who don't understand meter reading. Hence, they do not know the used amount of electricity. The aim of the work is to design and develop a real-time low- cost energy meter monitoring systems integrated with cloud services along with an android application. In [7] the author proposed a Wi-Fi based single-phase smart meter based on IoT. The author used a digital meter, ESP8266 Wi-Fi module and a web application for the user interface. The ESP8266 Wi-Fi module has attached into the meter. The ESP8266 Wi-Fi module has been implemented by TCP/IP protocol as the means of communication between the meter and web application. The proposed system is secured and open source but costly. The system consists of the electricity meter which measures the electricity bill and informs the consumer about the number of units consumed and associated costs with it. The micro controller coordinates the whole system with the help of its different components connected to it.

In [8] an Automatic Meter Reading (ARM) based Power Meter with Wi-Fi Communication Module scheme has been proposed and developed software based on Linux. In [9] the author presented a survey report on the utilization of smart electricity meters and some key aspects of the metering process. As well as opportunities arising due to the advent of big data and the increasing popularity of the cloud environments challenges are highlighted by the author. In [10] the author proposed a system where Arduino Uno has been developed with an Ethernet shield that can monitor all the necessary activities in the flow of electricity, the use of current and electricity costs and mentioned hope of reducing the problems associated with payment, calculate the cost of the unit of electricity. In [11] the idea of smart energy meter using IOT and Arduino have been introduced. Energy meters which is already installed at houses are not replaced, but a small modification on the already installed meters can change the existing meters into smart meters. Users will get a notification regarding energy consumption. In [3] the author proposed a real-time monitoring system for residential energy meter. The presented system provided inclusive and continuous access to energy consumption to the consumer by exploiting the advancement of IoT technology.

3. Architectural Model

The system consists of hardware and software part. In the software part all programs are located in Arduino Uno, using c language. Arduino is the main controller which connects energy meter, GSM module and other sensors so that they can communicate with each other. And Arduino can only work after the designed program is uploaded into it. There some factors which needs to be considered in order to a meter as a smart meter which includes:

1) Real-time or near real-time capture of electricity usage and possibly distributed generation.
2) Providing the possibility of remote and local reading of the meter.
3) Remote controllability of the meter enabling control and even cut off the supply.

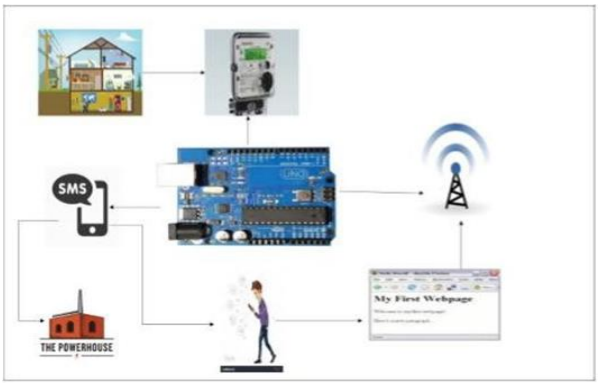

Fig. 1. Architectural diagram

The architectural setup is shown in Figure 1. The proposed system is divided into three major parts. They are Energy meter region of the customer, Wamp server region and Application interface for the customer.

1) Energy meter region of customer

This region consists of two electric meters, two devices and a Wi-Fi network. The devices have been connected with the Wi-Fi network to transfer data in the cloud server. The devices are being mounted on the energy meter to fetch the pulses. The received pulses are being transferred to the corresponding accounts of customers created in the cloud server. The customers need to be registered using the Android application as well as login their account and can request to access all of their information regarding energy consumption.

2) Wamp Server region

A database is created into the cloud server for each device. Each device fetches pulses from the energy meter which is converted to kilowatt and transferred into the database.

3) Application Interface for customer

The users can view all stored data in the wamp through an android application. Users can request information on their registered accounts by log into corresponding accounts. To login, the user has to input user id and password as a means of security. After login, the user can view the number of consumed units, received pulses, total cost, details of the Wi-Fi network. A help manual guide the users to use the application. In the case of pre- paid, users set an initial balance of recharged money. The application automatically calculates the number of consumed units and notifies the users when 80% of the balance of recharged money has been paid.

The user can set the threshold value on webpage with the help of Wi-Fi. When the power consumption reading is about to reach the threshold value a notification will be sent to the user. This notification helps to create awareness about the energy consumption. If the consumer wants to change the threshold value, he can visit the web page and change the value. If the consumer is not aware of the threshold notification, then the meter will automatically get off. Finally, the overall monthly bill with cost will be sent to customer as well as service provider in the form of text. This will reduce human dependency for billing, problems of errors in bill etc.

4. Implementation

A smart energy meter is the combination of hardware and software. The software part i.e. all programs are included in the Arduino Uno using c language which controls all the operation. Hardware components such as Energy meter Nodemcu microcontroller, Energy Meter with opto coupler for connecting with processor, appliances connected through relays, Wi-Fi module, Switching Device etc., are used in the system. The Arduino Integrated Development Environment (IDE) is a cross-platform application (for Windows, macOS, Linux) that is written in functions from C and C++. It is used to write and upload all the programs to Arduino compatible boards, but also, with the help of 3rd party cores, other vendor development board. WampServer refers to a software stack for the Microsoft Windows operating system, created by Romain Bourdon and consisting of the Apache web server, Open SSL for SSL support, MySQL database and PHP programming language. Android Studio is the official integrated development environment (IDE) for Google's Android operating system, built on JetBrains' IntelliJ IDEA software and designed specifically for Android development. It is available for download on Windows, macOS and Linux based operating systems. It is a replacement for the Eclipse Android Development Tools (ADT) for native Android application development.

The proposed system uses NodeMCU Processor that can process the instructions according to our requirements such as power delivered to appliances and status of devices which is on state or off state. The hardware setup implemented is shown in Figure 2. The control signals generated through Wi-Fi are fed to the microcontroller which will drive the appliances that are connected to NodeMCU through energy meter. The energy meter that is connected to NodeMCU through pc 817 opto coupler will regularly calculates the number of units consumed and the billing amount. The same will be displayed on LCD along with the same information will send to web server about number of units consumed in terms of graph.

Fig. 2. Energy meter

We could able to reduce the consumption of power by switching off through web links that are defined while programming the web server and NodeMCU. As we are

defining the prepaid energy meter we need to refill the number of units that are required approximately per month by estimating the consumable load. However, we could able to add the units if completed early. Units are remained at the end of the month will added to next month if they done the refill before consumption of remaining units. The detailed billing graph will be provided in web server which can be accessed by giving the user details. The whole arrangement provides an effortless, convenient, quick and smooth navigation experiences. The hardware implementation of this projected system consists of an NodeMCU microcontroller, Energy Meter with opto coupler for connecting with processor, appliances connected through relays to micro controller.

Using energy meter with NodeMCU utilizing the beat LED (Calibration or Cal) of power Energy meter. Here just need to associate this CAL LED to NodeMCU through an Opto coupler IC. At the point when power up the framework then it peruses past estimations of rupees put away in the database and reestablishes them into the factors at that point checks the accessible parity with the predefined worth and makes a move as indicated by them. NodeMCU kills the power association of home and sends a SMS to the client's telephone for 'Light Cut' alarm and mentioning to revive. When the various appliances of household consume energy the energy meter will read the reading continuously. In this system NodeMCU, which continuously monitors the energy meter. There will be LED on meter continuously blinks which counts the meter reading. According to blinking of LED on energy meter the NodeMCU will measure the unit consumption. The measured reading and the calculated cost will be displayed on the web page designed.

Smart Meters by continuously monitoring and sending feedback of data to the customers. We will have an Android Application which is connected to the electric meter. At the time of installation of the device, staff will generate a unique identification number for device. Staff will then embedded this number into the device and will also create a user account for the customer containing customer name, email, mobile number and address. The newly created device and user will be linked together. After successful installation of device and verification of the user details, customer will be provided with a password for checking status of their device with the help of email provided by the customer. Now the device is ready to be used. User needs to recharge this device from a web app designed for this device in order to continue supply of electricity. Through this device user can get to know the power consumption at their home or workplaces. They can get to know which electric device is consuming how much of energy through the website.

In the proposed method, the consumer can manage their energy consumption by knowing their energy usage time to time. This method not only provides two way communications between utility and consumer but also provides other functions that are if the consumer fails to pay the electricity bill the energy supply would be cut down from the utility side that is there will be no power supply in their places and once the bill is paid the energy supply is reconnected. It also notifies the consumer & utility at the event of the meter tampering. By this information the consumer & utility can control the tampering and reduce energy crises.

5. Components

Some of the components that are used in this system are explained below:

1) Energy meter

Energy meter is a meter. The design of this energy meter is such that the surrounding things do not affect its working. The construction is such that it is UART compatible i.e. the reading recorded through an energy meter is shared with the controller and displayed on the web page. It is mainly used to measure the energy consumed by the user. It is used in domestic and industrial AC circuit for measuring the power consumption. The basic unit of power is watts and it is measured by using a watt meter. If one uses one kilowatt in one-hour duration, one unit of energy gets consumed. So energy meters measure the rapid voltage and currents, calculate their product and give instantaneous power. There many types of energy meter exist.

2) Optocoupler

An optocoupler is an electronic component that transfers electrical signals between two isolated circuits by using light. Optocoupler prevent high voltages from affecting the system receiving the signal. In this system optocoupler is used as signal conditioning block. It indicates the count of power by continuously blinking the LED. When the LED blinks the diode will conduct, transistor will get active and it will give 5v at output which we are externally giving to transistor.

3) Arduino Uno

Arduino is the main part of this system. This board contains all the necessary peripherals that need to support the microcontroller onboard. It has a very simple interface with the computer such as USB. Arduino responses to the supply given by opto-coupler. The Arduino microcontrollers are programmed with a boot-loader which facilitates easy uploading of the programs on to the on-chip flash memory. A program that is to be dumped on to the Arduino board can be done via a serial connection to the host computer. Thus, the Arduino board can be programmed to interface with the solder less breadboard. The advantage of using Arduino device is that it is easy to program and cost effective as compared to other controllers. It keeps on counting the supply and calculates the power consumed and also the corresponding cost. This data it continuously stored in the web page where the user can visit the page and get the details about the power consumption.

4) Wi-Fi module

Wi-Fi module acts as a main part of the IoT system. Wi-Fi stands for Wireless Fidelity. Through this module the user can set the threshold value and can ON and OFF the energy meter.

It helps to display the readings of units and costs time to time on the web page. So the consumers can access the energy meter through Wi-Fi module.

5) Load Relay

Load relay controls the load. It is located in the middle of the load and energy meter. This relay is used to control the load remotely.

6) Power Source

Power Source is the supply received from the utility which is given to the energy meter through the master relay. This supply is used to obtain a 5V regulated DC supply for the controller.

7) Load

In smart energy meter the load is simple or domestic that is CFL bulb, LED bulb, fan, etc this load is interfaced through the controller with help of sensors and other transducers. By using the feedback obtained from sensors and the relay operation the load can be controlled.

8) Web Page

This is the web portal through which the daily energy consumption can be monitored; the graphical representation can be seen. The daily limit of energy usage can be set. The switching of any load can be done. The web page will have an admin login option so that we can keep our system secure. This page can be accessed by both utility & users. But our meter works on pulse which is created according to consumption and we previously connected an android board which monitors the pulse and evaluates if it reaches the threshold then cuts off the connection. With the help of this project we are aiming to receive the monthly energy consumption from a remote location directly to the centralized office. In this way we can reduce human efforts needed to record the meter readings which are till now recorded by visiting every home individually.

6. Advantages

The Main Advantages of this technique are:

- It is exceptionally exact as of the entire thought of perusing the units and afterward charging physically or some other methods is dispensed with.
- The purchaser can't escape from taking care of the power tab and the State Electricity Board gets liberated from obligations.
- On the customer front, the dull undertaking of taking care of the tab and standing by tensely for the bill is wiped out.
- Wastage of vitality is decreased as now just the necessary vitality will be expended as distributed.
- The force network can screen the general vitality utilization and any altering endeavors are really of no utilization and can be identified if still prevail.

7. Disadvantages

- The NodeMCU should be always connected to the mentioned Wi-Fi and a continuous uninterrupted internet connection is required to get accurate reading on the server platform.
- Components are quite expensive.
- When a part of the system is damaged, replacement of whole component is necessary.
- We can get value from Kilo Watt Hour format if we can keep the system ON for an hour or more.

8. Conclusion

This paper proposed an IoT based smart energy meter which is helpful to track the energy consumption for the user. It calculates the units of power consumed by the user and corresponding cost. This data can be accessed by the user through a web page. So there is no need of human intervention. This system also provides a facility to set the threshold value. When this limit is exceeded user will get an alert notification. This feature helps control the energy consumption. Hence, it reduces the wastage of energy and helps in creating the awareness about energy consumption.

In future we can upgrade it so that if there is any abnormal readings then it can send a warning message through internet connection. We are trying to make it a market product which will be able to provide the data regardless of being offline or online.

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