IoT Enabled Smart Energy Meter for Efficient Energy Utilization in Household and Industry Applications

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Abstract

The rapid increase in the human population and industries will give raise to the need and demand for electricity. In the current scenario, the electricity bill (unit and amount for power consumption) can be calculated manually through the electric bill reader for consumers in their residence for every two months once. The consumer can get the amount details through the registered phone number for their benefit. In the existing system, the bill reader needs to examine the meter of every residence. While recording the manual reading, the accuracy may be reduced. To overcome the existing problem, the smart energy meter is introduced using internet of things, which pre-intimate the power agenda using Arduino NANO and GSM module. The Arduino controller is used to calculate the total cost of the energy consumed and the SMS will be sent to the registered phone number of the consumer immediately. This system introduces the Thing speak IoT open source platform which can be used to record the periodical energy utilization (daily) and cost of the power consumption in cloud database and also able to view the graphical representation of the power consumed for the service provider(TNEB) as well as the consumer. It helps the consumer to aware about the energy utilization for a period of time and bill payment due date details through warning alert by buzzer. In order to reduce the manual errors and to make appropriate automatic measuring of power, the proposed system is implemented which increases the accuracy and helps to save the energy conservation for the consumer without any human intervention.

Key words: Energy meter, Meter reading,

1. Introduction

Many useful internet applications can be produced due to the technological advancements in IoT technology. Actually, IoT is a network in which physical objects are connected to the internet in order to exchange the information. IoT controls the objects remotely across the current network infrastructure. IoT is an excellent and intelligent technique that reduces human effort and gives quick access to physical devices. This technique includes autonomous control feature through which any device can be controlled without human interaction. Examples include Home Automation System, which uses Wi-Fi or Bluetooth for exchanging data between various devices of home. The current IoT status is in rising stage, so large applications are developed in the market based on internet of things. The current world will soon develop into a better place for communication with peoples. Thus, in future the world will provide huge amount of facilities to stay in connection with the internet. In today's popular sectors, the advancement of technology development and research on wireless applications has become more significant. An electricity meter is a device, which measures the consumption of electricity in a residence, or an electrically powered device. A smart energy meter (SEM) is an electrical device, which consists of an energy meter chip for electric energy consumption measurement, wireless protocol for digital communication (such as GSM Modem) and other peripheral devices for security purpose.

Energy meter system often consists of embedded controllers like GSM modem, which transmit the information over the mobile network. Such data will be fed to the existing Energy Management Systems located at the power organizations. The Energy Monitoring System is acceptable for Industries, manufacturing plants, commercial buildings or any situation where an electrical system is employed. The energy management system monitors and saves the overall cost. The smart energy meter contains an energy meter, a GSM modem, WIFI module and a microcontroller (Arduino NANO).

2. Related works

Bibek Kanti Barman et.al defines about the efficient energy utilization in smart grid. Monitoring and controlling is the prioritized work in smart grid. This smart energy meter uses ESP 8266 12E, a Wi-Fi module to control and calculate the energy consumption which will be uploaded in cloud for everyone's view. This also helps in theft detection in power [1]. **Nanda Kishor Panda et.al** proposed a system, which designs a compact, and portable real-time setup that collects and install the data through a clamp which offers an IoT platform where the consumers will monitor and interact. The system is safe in design and has an accuracy level of 97% and it is about 30% lower costs in the market [2]. **A.Y.Devadhanishini et.al** this paper deals with the WIFI as well as the GSM to update the data to the consumers. They also make use of the motion sensor to detect if the consumer is available there or not, if the consumer is not available, it cut off the power by itself to limit the power consumption so that the consumers can be benefitted [3]. **A.R.Al-Ali et.al** confesses about the planning, development, and testing of an integrated Internet of things based smart utility meter, which monitors the consumption of electricity, water, and gas. This meter operates with a unique network address and programmed remotely to read the three utility consumptions at any desired frequency, which is fixed by the utility service providers. The meter can be activated either through private computer or through a mobile handset. Google Map markers will show the status of meter whether connected or disconnected [4]. **K.Anitha et.al** in this project the planning and implementation of an energy monitoring system using Arduino micro controller and a GSM (Global System for Mobile Communication) module. This technique facilitates about the day-to-day energy consumption and helps in energy conservation. From the electricity board the bill amount and the payment are the pre-planned power pack details that will be shared to the buyer. If the bill is paid on time, the user will be informed through a message. If persists, one alert message will be sent then automatically power connection will be disconnected [5]. **Mohammad hossein yaghmaee et.al**, this paper uses the GSM for delivering the message of consumption and its cost to the consumer. They also uses gateway for receiving information from the sensor in the meter and deliver it to the controller or server. This information can also be updated in the cloud and view it as a graph for clear understanding. They also reduce the consumption at peak hours [6]. **Aditya Tiwary et.al** proposed that the consumer must be aware of their power usage and alert them to reduce the power wastage. They make use of the ARM processor to enable the system and make the system smart and reliable. It is used to calculate the power consumption of the household and make the readings in quite handy [7]. **Vishwa Kotecha et.al** proposed a system, which interfaces between the microcontroller and the energy meter for unit values and GSM Technology. This executes logical functions and store data in SQL database so that the monthly bill will be sent to the consumer telephone number, which disconnects for non-payment and reconnects immediately after payment [8].

Osmi Jaiswal et.al proposed a wireless method which emphasis on Intelligent Energy meter (IEM) reading and bill generation using Arduino Mega and Ethernet Shield. The monthly generated bill are going to be sent to the buyer through SMS using GSM900 and power of unpaid consumers would be disconnected employing a relay which might be controlled wirelessly using the concept of Internet of things (IoT) [10]. **S.Shahnawaz Ahmed et.al** a completely unique scheme has been proposed where the consumers will use their mobile cameras to require the photograph of respective meter's display board alongside the kWh (kilo-watt hour) information once a month and send it as a picture to the utility servers using the MMS (Multimedia Message Service) from their mobile phones. The server will process the image, retrieve the kWh information, convert it into a text (number) and archive it against the consumer's mobile number or identity code [11].

3. Proposed system

In this project, electricity usage is updated periodically that is read from the energy meter and then sent to Arduino NANO microcontroller, which is interfaced with GSM module and LCD to send and show the status of the usage of power respectively. This Figure.1 shows the block diagram of the proposed system. The proposed system consists of the electricity meter, which is connected to the power supply, which will be given to the transformer that converts it to the 5V supply and supplies it to the loads (eg.bulb). When the supply is given, the load will consume some power. The flash of the LED can calculate it for every 3.6 seconds from the IR sensor. When the supply is given, the load will consume some power. The flash of the LED can calculate it for every 3.6 seconds from the IR sensor. This data is given to the Arduino NANO .The Arduino is connected to the Node MCU and to the GSM by connecting the SIM card and through the MCU; the information can be uploaded to the cloud.
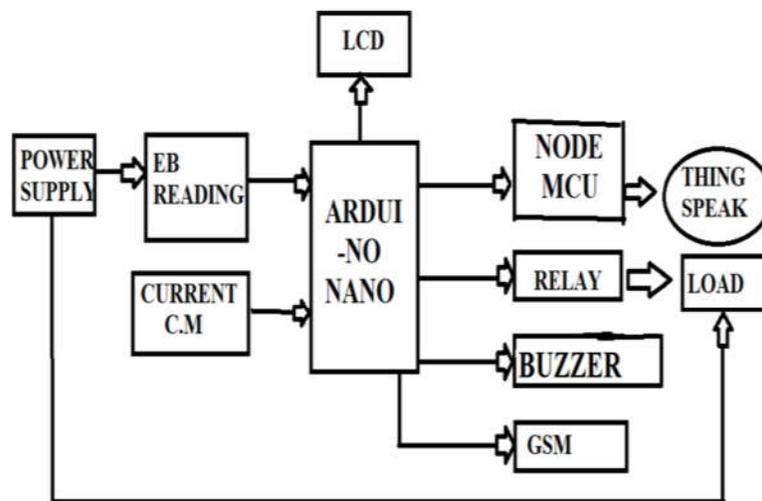
Figure.1 Block diagram of IoT enabled smart energy meter

Using Thing speak, an open source platform. From the GSM, the message regarding the consumption of power and its estimated cost will be sent to the consumer as SMS. In addition to that, a relay system has also been used to make the power connection ON/OFF if the consumer fails to pay the electricity bill payment.

Before switching OFF the connections, a warning can be made by setting the buzzer sound ON. The IoT itself can control this buzzer system. So, the consumer at home can be alerted regarding the bill payment. This consumption can be read from the LCD connected with the electricity meter, which displays the unit of power and amount of every unit and the graphical view of the same can be displayed in the think speak.

3.1 Hardware description

3.1.1 Arduino NANO

Arduino NANO is different from other Arduino because it is very small and suitable for small sized projects and it can be plugged with other components. It is a complete, breadboard friendly board based on AT Mega328P. It can work with a Mini-B USB cable instead of a standard one. Each of the 14 digit pins on the NANO can be used as an input or output. They can operate at 5V. It has a number of ways for connecting with the computers and other microcontrollers.

3.1.2 Node MCU

Node MCU is a low-cost open source IoT platform. To support for the ESP32, 32-bit MCU is added. Node MCU is an open source firmware that has open source prototyping board designs. The term "Node MCU" properly speaking refers to the firmware instead of the associated development kits. Both the firmware and prototyping board designs are open source. It consists of the WIFI module to connect to the internet.
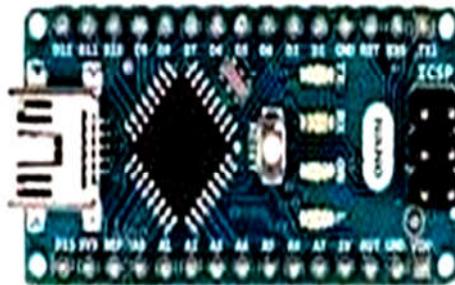

Figure.2 Arduino NANO   Figure.3 Node MCU

Figure.4 GSM Module   Figure.5 Liquid Crystal Display (LCD)

3.1.3 GSM Module

GSM is the Global System for Mobile Communication is a digital network that is widely used by the people in the world. The GSM uses the TDMA (Time Division Multiple Access) and CDMA (Code Division Multiple Access) variations. The mobile devices will be connected using hardware and identifies through the Subscriber Identity Module (SIM). Through these connections the mobile phones can accessed.

3.1.4 Liquid Crystal Display (LCD)

The 16×2 liquid crystal display is used in the project. It is the basic and commonly used LCD display. It has 2 rows and 16 characters. This will be interfaced with the microcontroller. The microcontroller will send two information for LCD operation. That is Data and Commands. Data will be in ASCII value. Commands will represent the operation of LCD.

3.2 Software description

3.2.1 Thing speak

According to developers, "Thing Speak is an open source platform for Internet of Things (IoT) application and Access Point Index (API) which stores and retrieves data from things by the HTTP and MQTT protocol. Thing Speak enables the user to view the status updates about the creation of sensor applications, location tracking, and social networks". It features about the relationship with Math works, Inc. In fact, all the documentation will be incorporated in the Math works' Mat lab documentation site and even enabling registered Math works user accounts as valid login credentials on the Thing Speak website. The terms of service and privacy policy of ThingSpeak.com are between the agreeing user and Math works, Inc.

4. Results and discussions

Each consumer has a unique consumer ID and password for log in into Thing Speak. After logging in to the Thing speak, the consumer can view the power consumption and cost for the consumed power in graphical representation. The figure.6 shows the log in information for the user. There is also an option for forgot password. The figure.7 shows the rate of consumption of power. The figure.8 shows the unit cost of power consumption. The figure.9 shows the unit of power consumption. The figure.10 shows the on and off condition of power consumption by turning on and off the relay.
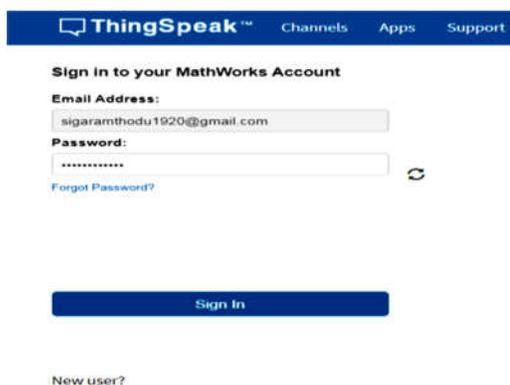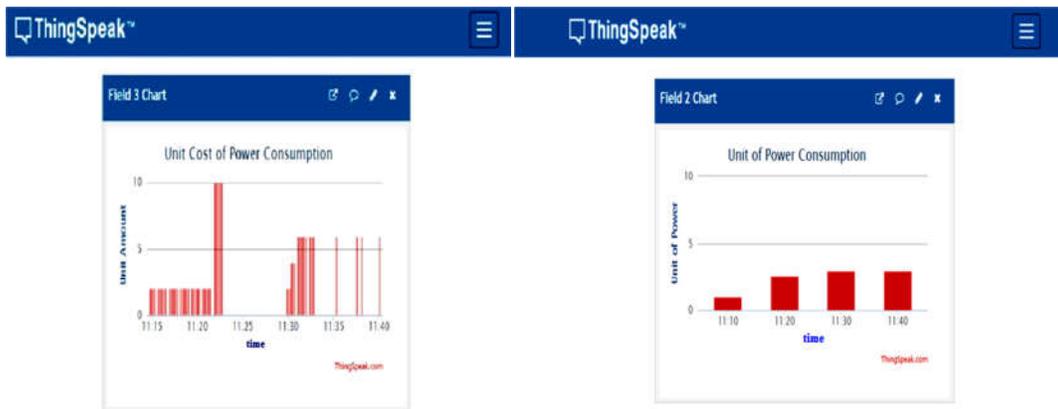

Figure.6 Login information for the user   Figure.7 Rate of power

Figure.8 Unit cost of power consumption   Figure.9 Unit of power consumption

Figure.10 Switching status

5. Conclusions

This project is implemented for automatic recording of the electricity meter reading and sending the SMS to the consumer as well as to the electricity board. Until now there is only manual meter reading is available in our nation. Through this system, people of the country will be aware of their consumption of power regularly (daily) through the SMS. The cumulative amount of power consumed will be sent to the consumer's mobile number for twice in a month. Thus the people will get clear decisions that how to consume energy, for example not leaving the TV on standby mode for hours. The LCD will display the status and the GSM will send the SMS to the user's mobile by this a knowledge about consumption will be gained. At the end of the sixty days, it sends the bill to the users and the service provider. In future, this work can be integrated with the complete automation of fuel and water consumption in industries and this can be developed into an Application (APP) for consumer's benefits. The device, which consumes more power, can be found from the system and the alternative way of using power can be made. This project achieves the high accuracy in the measurement automatically for the energy conservation.

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