Monitoring and Controlling Energy Consumption Using IOT and Blockchain

V.Subbulakshmi
Department Of Information Technology, Velammal Engineering College, Chennai.
Email: vsubbulakshmi90@gmail.com
D.Aiswarya
Department Of Information Technology, Velammal Engineering College, Chennai.
Email: aishudeena10@gmail.com
A.R.Arulselvi
Department Of Information Technology, Velammal Engineering College, Chennai.
Email: ararulselvi@gmail.com

ABSTRACT

Electricity is one of the most powerful forcein our lives. Almost every device in homes and industries run with the help of electrical energy. Thus this energy should be utilized effectively so that they can be saved for future generation. Internet of Things(IoT) refers to the network of physical objects where each object can be accessed through network. These objects should be synchronized so that they can communicate with each other. But, when the number of IoT devices increase, synchronization becomes an issue. In such situations blockchain can be used to control and configure those IoT devices. Blockchain is a digital ledger which is used to record transactions. Each block contains the hash value of previous block and transaction data. Thus transactions are secured effectively. This paper proposes an IoT system that continuously monitors electrical energy consumed by various electrical devices and if it reaches a certain threshold value, the devices will be automatically turned off or switched to power saving mode. In order to ensure security, the amount of energy utilized by IoT devices and the threshold value provided by user, is stored in a local server using the concept of blockchain technology. An Android application which is used to get limit value from the user also provides alert notification when the energy consumed by the devices reaches ninety percent of the threshold value. Upon receiving the notification, the user can take decision whether he wishes to increase the threshold value or not. If energy consumed exceeds the limit, the devices will be automatically switched to power saving mode. Hence the electricity is well conserved for future generations.

Keywords - **IoT, Android, Blockchain;**

I. INTRODUCTION

Electricity is the vital requirement for leading a comfortable life.The invention of electrical devices and appliances have greatly simplified the life of individuals. Household devices such as refrigerators, air conditioners, microwave oven, vacuum cleaner, lights, water heater, fans, etc. use electricity. In addition to the above mentioned, electrical energy is being consumed by industries, business organizations, etc.

With the rise in the standard of living of the people the electricity consumption has also increased.India generates around 1,160 billion units of electricity according to a census taken in the year 2017. The third largest producer of electricity is India. As human population increases, consumption of electricity has also increased. Average electricity use in India was 1,122 kWh per capita in the year 2016 which has increased to 1,149 kWh per capita in the year 2017. There are many reasons for increase in the energy consumption. One such reason is the increase in the number of industries. The consumption of electricity has also increased due to its wastage in household appliances which is usually not known to the consumer.

The raise in energy consumption due to its unwanted loss led to the development of various energy consumption monitoring systems. The main objective of these systems is to monitor the amount of energy consumed and control the wastage of electricity. By the advent of new technologies like Internet of Things(IoT) led to many new innovations. Among those innovations smart meter plays a very important role in managing power consumption.

IoT provides a network through which sensors can share data with one another. The internet of things belongs to the branch of application programs for collecting data in real time from multiple devices installed at remote locations to control those devicesby setting conditions. The major requirement for providing communication among these devices is Internet. This technology is used extensively in constructing smart home, enhancing transport facilities, providing support for elder care, etc.the IoT has become the foundation for developing opportunities for providing more direct integration of the physical world into computer-based systems, thereby improving efficiency, economic benefits, and reducing human strain.The data gathered from sensors installed at remote locations needs to be stored in secure place. It is vital to protect the data from hackers. Security should also be ensured when the

information collected is transmitted through network from sensors to the database.

II. LITERATURE SURVEY

The traditional way of calculating the energy consumed by household electrical devices is that, an energy meter is installed at a person's house. This energy meter continually monitors the energy consumed by all household electrical appliances such as refrigerator, air conditioner, washing machine, television, lights, fans etc. An authorized person from the electricity board periodically visits the physical location where the energy meter is installed to record the readings. Based on this data, the billing information based on the units of energy utilized by the consumer will be communicated manually by the electricity board.

In order to reduce the human exertions, an Automatic Meter Reading(AMR) Technology was developed. By this technology, the authority from the electricity board or the utility provider is not required to visit the individual's home to audit the energy readings. Instead, the readings from the energy meter are directly sent to the provider without any expense of seasonal trip to each of the physical locations to make note of the readings. The data can be sent directly to the central database for billing and accounting purpose.

As advancement to the AMR technology, smart meter was invented. Smart Meter is an electronic device which aims at monitoring the electrical energy consumption by electrical appliances without requiring visit to consumer's home. It is an Advanced Metering Infrastructure(AMI), providing two way communication between the electricity supplier and the consumer. The data from energy meter can be viewed by both the supplier and the end user. By this, user can view the amount of energy consumed continuously and take necessary measures to conserve it.. Based on the amount of energy consumed, bill to be paid by the user will be generated and sent to him. Thus this minimizes man power and automates the billing process.

III. DISADVANTAGE OF THE EXISTING SYSTEM

- The existing system provides no support to turn off the devices or put them to power saving mode when certain power consumption limit given by the user is reached.
- Any attacker can eavesdrop the meter readings which provide information about amount of energy consumed by the user and may tend to modify them.
- No notification system exists to alert the consumer based on the power utilized.
- User has no control to limit the energy consumed by household electrical appliances.
- Wastage of electricity cannot be controlled, hence the electricity bill to be paid by the consumer is huge.

IV. PROPOSED SYSTEM

In this paper, we present a real time method to monitor and control the power consumption using the concepts of Android, Internet of Things and Blockchain. Our aim is to design an Android application through which an end user can set the maximum amount of power that can be consumed by electrical appliances. The android application also helps the consumer to view the current usage and get a notification on amount of energy consumed. The household electrical devices are interconnected to the energy meter through the concept of Internet of Things. Upon reaching the threshold value set by the user, the electrical devices are either turned off or put to power saving mode. This prevents unnecessary loss of energy. Also the user is able to reduce the amount of bill to be paid. The data received from the android application and the smart energy meter is recorded in the database by the concept of blockchain. In order to provide synchronization when large number of IoT devices are used, Blockchain concept is used. Blockchain easily configures and controls hundreds of thousands of IoT devices. It ensures security of data stored in server by storing the hash value of previous block in next subsequent block. Thus if an intruder wants to modify the original data, he needs to change it in all the blocks which is a tedious task. Hence it can be guaranteed that no modification of data occurs during the transmission across the network.

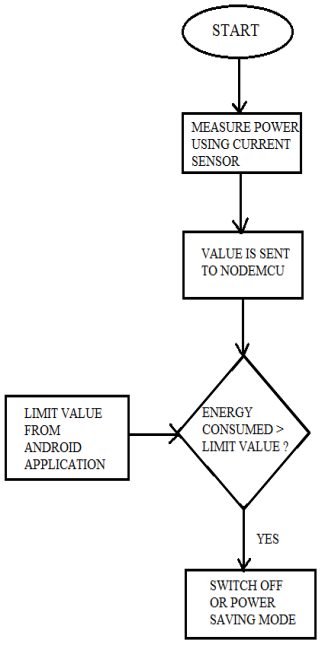

Fig 1: Workflow diagram of monitoring and controlling energy consumption

The above flowchart depicts the workflow of the proposed system. Initially the user will be asked to enter the threshold using an android application. The value from the android application will be stored in a local server using blockchain. Energy consumed by the device will be continuously monitored by current sensor and the value will be recorded in database of a local server by the

concept of blockchain. If the energy consumed exceeds the threshold, the device will either switched off or enter into power saving mode.

V. MODULES

Three modules are used in this system.

- Android application
- Smart meter
- Blockchain

5.1 Android application

Android is a mobile operating system primarily designed for mobile devices, tablets, PDAs' etc. It has massive user base since it provides excellent user interface for communication. In our proposed system an android application is used to set a limit up to which electrical devices can consume energy. It provides interface for the users to log in to the application and set the required threshold value. As the first step, the user is required to connect to the local server by entering the IP address. On successful connection, user can access the application by entering his/her valid login credentials(username, password). If he/she is a first time user, then it is mandatory to complete the registration procedure. The details acquired during registration are stored in the database. While signing in, the credentials provided by the user is validated against those stored in the database. If there is a match then he is considered as an authorized person and provided access rights. If the credentials do not match, then the user is restricted from accessing the software application.The android application, enables the authorized user to monitor the total amount of energy consumed by various electrical devices. Basedon this information, the authenticated person can provide the threshold value, which when reached by the readings from the energy meter, devices are either turned off or put to power saving mode. In addition, the android application also has a feature to provide notification alert to the user when certain percentage(say ninety) of the threshold value is reached. The following flowchart portrays the algorithm of android application.

5.4 Smart Meter

Smart meter is the IoT-based system that monitors the energy consumption of electrical devices. The hardware components used are

- Current sensor
- NodeMCU
- Power supply
- Relay

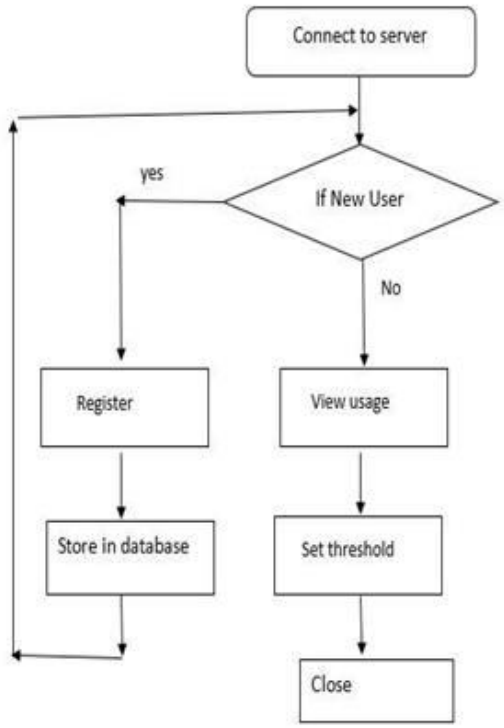

Fig. 2: Flowchart diagram of monitoring and controlling energy consumption

Current sensor is the device that is used to measure the amount of energy consumed in various electrical devices. This device records the amount of energy consumed, by sensing the energy flow through the electrical wire. It measures the voltage in the appliance without affecting its performance. The basic principle of direct sensing of current is Ohm's Law, which states that the current flowing the conductor is directly proportional to the voltage difference between the two points. Based on this principle we can calculate the amount of current utilized by any electrical device.

The value measured by the current sensor is sent to nodeMCU. NodeMCUis a micro controller that uses ESP8266, a WiFi module chip which connects various IoT devices. It is an LUA based hardware that performs various functions. LUA is efficient, powerful, embeddable scripting language that supports procedural programming, functional programming and object oriented programming. NodeMCU has a built-in analog to digital converter. Using this, the analog input signals from the current sensor is converted into digital signals and stored in the database.

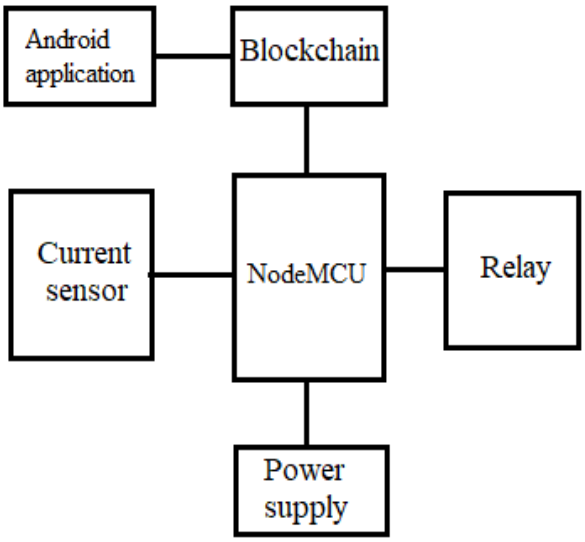

Fig 3: Design Model for the monitoring and controlling energy consumption

A relay board is an electromagnetic switch that operates using relatively small amount of electric current which can turn on or off a much larger electric current. The core of a relay is an electromagnet (a coil of wire that becomes a temporary magnet when electricity flows through it). This device is used for turning off certain electrical devices when the energy meter reading reaches the threshold value. Both the NodeMCU and the relay board requires power supply for operation.

5.4 Blockchain

The data from android application and smart energy meter(NodeMCU in specific) is stored in the local server using the concept of blockchain technology.

Blockchain is an evolving technology, to secure the data transmitted in the network. The core concept of this technology is that, the data to be transmitted is stored in form of blocks. Each block holds the transaction data and the hash value generated from the previous block. Hence it is difficult for an intruder to hack the network and modify the data. The four basic operations in blockchain technology include:

- Determining participants in blockchain
- Gathering valid transaction data from those participants
- Generating and signing blocks of valid transactions
- Distributing blocks to participants.

When there occurs a mismatch in the data stored in two different nodes, then the data is said to be corrupted. The following picture shows the implementation of the proposed system. It is built by considering one of the household electrical devices(light bulb). But the proposed system can also be extended on multiple devices. The setup shows that the electric bulb is connected to the power supply. A current sensor is attached to calculate the amount of energy consumed by the electric bulb. The reading from the current the current sensor is given to one of the analog input pins in NodeMCU. Internally the nodeMCU converts the analog data and generates digital signals. These digital signals are stored in the local server through blockchain which is implemented by Spring Boot Framework. SHA-256 algorithm is used for generating the hash value from the data. This framework helps in storing and retrieving data from the database. With the help of LUA program written in the NodeMCU the readings from the current senor is continuously monitored. When the threshold value mentioned by the user is reached, the electric bulb is turned off. This is done with the help of 2 Channel Relay Board. Both NodeMCU and the Relay Board are connected to a power supply.

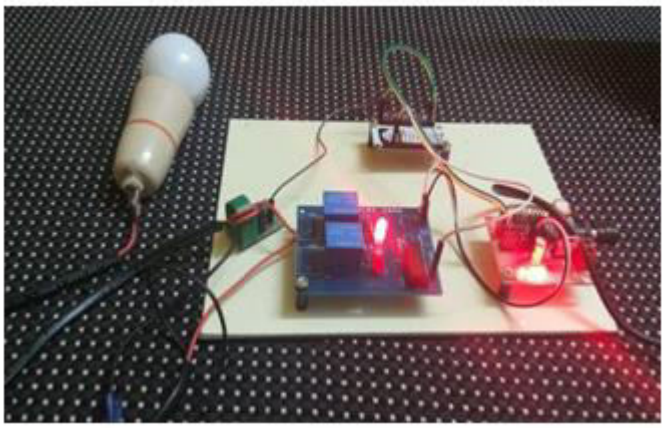

Fig 4: Implementation

5.4 Advantages

- Manual monitoring of electricity usage from the meter readings is not required.
- Automatic switching from normal mode to switch off or power saver mode is implemented by this system.
- Authentication of participating entities helps users to block unauthorized access.
- Synchronization of IoT devices becomes easier as blockchain is used.
- Security is also enhanced with the help of blockchain.
- Economically benefits the consumer by avoiding unnecessary bills on electricity wastage.
- Use of Android application enables easier access

VI. Conclusion and Future Enhancements

In this paper we proposed an idea for monitoring the consumption of electrical energy by household electrical devices and controlling the unnecessary loss of electrical energy by combining IoT and Blockchain technologies. A smart meter which constantly monitors electricity consumption of devices is designed. An android application which is used by the user to set the limit value is developed. Using the android application, the consumer can also view the total amount of electrical energy

currently consumed by the appliances. He is also provided a notification alert when ninety percentage of the specified threshold value is reached. Using this information, he may either extend the threshold value or takes precautions to control the electricity. The two reading from the android application and the smart energy meter is stored in a database using blockchain technology. These values are compared and if the energy consumption exceeds the limit set by the user, the device will be turned off or switched from normal mode to power saving mode. The main disadvantage of the proposed system is the need for Internet to provide communication among the electrical devices.

We experimented this idea on a single electric bulb. In future we would like to extend this work to monitor and control many electrical devices thus developing a fully-scaled IoT system containing number of IoT devices, whose energy consumption will be continuously monitored thereby conserving electricity for future generations.

REFERENCES

[1] M. Prathik,K. Anithaand V. Anitha,"Smart Energy Meter Surveillance Using Iot", 2018 InternationalConference on Power, Energy, Control andTransmission Systems (ICPECTS).

[2] WessamMesbah, "Securing Smart ElectricityMeters Against Customer Attacks", IEEETransactions on Smart Grid,Vol. 9, Jan. 2018 .

[3] Eslam Al-Hassan,HussainShareef, Md. MainulIslam,AddyWahyudie, Atef Amin Abdrabou, "Improved Smart Power Socket for Monitoring and Controlling Electrical Home Appliances", IEEE Access,Vol. 6, pp. 49292 - 49305

[4] ParaskevasDeligiannis,SteliosKoutroubinas,George Koronias,"Predicting Energy Consumption Through Machine Learning Using a Smart-Metering Architecture", IEEE Potentials,Vol. 38, March-April 2019 ,pp. 29 – 34

[5] Yanan Sun,Lutz Lampe,Vincent W. S. Wong, "Smart Meter Privacy: Exploiting the Potential of Household Energy Storage Units", IEEE Internet ofThings Journal,Vol. 5 , Feb. 2018 ,pp. 69 - 78

[6] Weixian Li, ThillainathanLogenthiran, Van-Tung Phan and WaiLok Woo, " A Novel Smart Energy Theft System (SETS) for IoT based Smart Home", IEEE Internet of Things Journal.

[7] Donghuan Yao, Mi Wen, Xiaohui Liang, Zipeng Fu, Kai Zhang and Baojia Yang, "Energy Theft Detection with Energy Privacy Preservation in the Smart Grid", IEEE Internet of Things Journal.

[8] Mohamed Amine Ferrag, MakhloufDerdour, Mithun Mukherjee, AbdelouahidDerhab, LeandrosMaglaras and HelgeJanicke, "Blockchain Technologies for the Internet of Things: Research Issues and Challenges", IEEE Internet of ThingsJournal[9] Oscar Novo, "Scalable Access Management in IoT using Blockchain: a Performance Evaluation", IEEE Internet of Things Journal.

[9] GiulioGiaconi; Deniz Gündüz; H. Vincent Poor, "Smart Meter Privacy With Renewable Energy And An Energy Storage Device" , IEEE Transactions onInformation Forensics and Security, Vol. 13, Jan. 2018, pp. 129 - 142

[10] BibekKanti Barman, Shiv Nath Yadav, Shivam Kumar and Sadhan Gope, "IOT Based Smart Energy Meter for Efficient Energy Utilization in Smart Grid", 2018 2nd International Conference onPower, Energy and Environment: Towards SmartTechnology (ICEPE).

[11] M. Faisal,Tahia Fahrin Karim,Abu Ridwan Pavel, Md. ShahadatHossenand M.S. HossainLipu ,"Development of Smart Energy Meter for Energy Cost Analysis of Conventional Grid and Solar Energy",2019 International Conference on Robotics, Electrical and Signal Processing Techniques (ICREST).

[12] Roji Thomas Mathew, SreeramThattat, K.V Anirudh, Varma P K Adithya and Geena Prasad, "Intelligent Energy Meter with Home Automation", 2018 3rd International Conference for Convergence in Technology (I2CT).

[13] Yongxu Zhu, GanZheng, Kai-kit Wong, "Blockchain Empowered Decentralized Storage in Air-to-Ground Industrial Networks", IEEE Transactions on Industrial Informatics.

[14] HosseinShahinzadeh, Jalal Moradi, Gevork B. Gharehpetian,HamedNafisi and MehrdadAbedi," IoT Architecture for Smart Grids", 2019 International Conference on Protection and Automation of Power System(IPAPS