

IOT Based Power Management and Controlled Socket Using Blockchain

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Abstract - Internet of things (IoT) is the emerging and the fastest growing technology and it is a system with the capability of information exchange and actions over the wireless network without human intervention. Increasing the use of IoT devices day by day produces vast amount of data, which becomes a major security challenge in IoT. Synchronization becomes an issue when the number of IoT device increases. In order to avoid synchronization problems and security challenges, blockchain is incorporated. High security is established by using blockchain. To avoid these kind of security issues, blockchain is the best solution. A vital role in the realization of IoT system is played by the power management. The energy meter present in our house is not able send the information to the cloud and man power is also required to update readings periodically, manually errors might also take place, to avoid these kinds of problem, an IoT system is used to monitor the electrical energy consumed by various electrical resources and if it reaches the threshold value indicated, it gives a warning message to the user and automatically switches to power saving mode. For ensuring security, the amount of energy utilized by IoT devices and the threshold value set up, is stored in cloud and security is established by using blockchain technology. Blockchain ensures high security such that no data can be changed if once entered, so its immutable nature provides it a high security for IoT. Hence energy consumed can be limited and can be conserved for future generations.

Keywords: *Internet of things, Blockchain, Security, Smart energy meter, Cloud*

INTRODUCTION

Electricity has become a major requirement to lead a comfortable and peaceful life. The invention of appliances and electrical devices have made people to live in sophisticated lifestyle. Electrical energy is being consumed everywhere across the world in various areas like household needs,

industries, business organizations, etc. As our need and population increases, the consumption of electricity also increases. We can consume energy but that has to be done efficiently. But, the consumption of energy has also increased due to its wastage in many areas which is not usually known to the consumer. At present, the energy meter calculates power consumed digitally. A person from Electricity board comes to take reading from energy meter and based on that amount is calculated. If we exceed certain unit, we have to pay extra amount or penalty accordingly. This extra usage of electricity might be due to unwanted usage of current or due to leakage current. This cannot be controlled as the user is not aware of their usage. Some of the consumers can understand those readings on their own and control their usage. This led to the development of energy monitoring systems.

The main objective of these systems is to monitor the amount of energy consumed and control the wastage of electricity and directly switching to power saving mode. Energy monitoring can be done using Arduino and Global System for Mobile Communication

(GSM) [1] but this is not applicable for wider range of bandwidth. By the development of new technologies like Internet of Things (IoT) led to many new innovations. In those innovations smart meter plays an important role in managing power consumption. IoT is a network platform through which sensors can share data with one another. Industrial IoT has also been in the development of smart-Grids in many applications [2]. The IoT belongs to the branch of application programs for collecting data in real time from multiple devices installed at remote locations to control those devices by setting conditions like setting the threshold value. The major requirement for proper communication among these devices is Internet. The collected information is stored in cloud platform through internet of things. The cloud plays a major role in the cost of the hardware, time-to-market and medium of communication for data collection and analysis of that data [3]. When the usage of IoT devices increases then [4] each and every node itself is possible to attack, like DDOS (Distributed Denial- of-service) attack by applying more traffic to the one

node and try to collapse that node. While exchanging data, security becomes challengeable. Another challenging issue of using IoT is its centralized server which will be easy for the attackers to modify data and it leads to the major challenges like confidentiality, authentication and data integrity. In order to ensure high security standards, blockchain is the latest emerging technology which provides security for IoT. In blockchain, each block consists of Data: sender and receiver information of a transaction.

Hash: each block has its unique hash value. (SHA- 256). Previous hash: each block has the hash value of its previous block [8].

The data cannot be modified once entered in blockchain. If we modify the transactions in a block then it will change the hash of all of transactions, so it is impossible for hackers to modify or hack the data and it ensures high level of confidentiality and security.

LITERATURE REVIEW

The traditional method of calculating energy consumed is by using electric meter which is installed in each house. The energy meter continuously monitors energy consumed by different electrical appliances. An authorized person from the electricity board periodically visits the person's house as per norms and record the readings and calculate the amount. The unit of power used and amount is written in an authorized card. The payment was done manually. In order to avoid standing in a queue to make payment, there developed a digital platform to pay the required amount.

Another method was implemented in order to reduce the human exertions is Automatic Meter Reading (AMR) technology. In this method there is no need of any authorized person visiting individual's house. Instead, the readings from energy meter are directly send to the provider. The data can be directly sent to database for billing and accounting purpose.

An advancement to AMR technology is smart meter. It is an Advanced Metering Infrastructure (AMI). It also monitors the energy consumption and there is a two-way communication between electricity supplier and the consumer. By this the user can even monitor the amount of energy consumed and can conserve energy manually.

This method is more advantageous when compared with existing energy meter. All the data are sent to the consumers mobile via IoT and the GSM module and it is also displayed in the LCD. Therefore, it saves time and it helps to eliminate the human interference using IoT [12].

Wireless sensor network technology is also implemented in energy efficient utilization. For efficient stable power and long-term system adopts a Maximum Power Point Tracking (MPPT)circuitry [6].

In this system the user receives an SMS regarding the update in energy consumption and final bill is also generated along with it. The user can also reload via SMS [10].

This fuzzy logic-based device is used to discover the gadgets sleep time in a computerized home environment in light of Bluetooth Low Energy (BLE). Benefits of this technique improved device lifetime by 30% and the sleep time of devices that were inactive. The future scope deals with the use of Gaussian functions [11]

The existing method is not capable to detect fault if any occurs which may lead to extra or less billing. The leakage current is very tedious to identify. It cannot notify the consumption limit. Here security is not maintained so anyone can modify energy meter reading. This can even lead to theft of electricity. There

is no control to limit power usage. Electricity wastage cannot be reduced which may lead to pay more amount than used. There is no notification to say about power consumed. The consumer is unaware of the amount they need to pay. Wireless power transfer [9] is an elaborate process and it is not concerned with power management techniques. An integrated approach of addressing designing power management unit (PMU) is still need to be developed.

PROPOSED METHODOLOGY

Power consumption monitoring system measures the power used by each of the loads individually. In order to control power consumed, the concept of Internet of things and blockchain is used. This system is designed around consumptions of energy using microcontroller board. The current sensor and voltage sensor is used to monitor the current and voltage level of each loads. Arduino is the microcontroller which is used to control all the devices connected to the microcontroller. IoT is used for communicating information through internet. The Twilio is a cloud communication platform which is used to programmatically send and receive messages via mobile. The current, voltage and power values are recorded in blocks and stored in cloud. From the available data, the energy value is calculated and the energy cost of corresponding energy value is also calculated. The blocks of data in cloud are highly secured by blockchain technology. It is guaranteed that no modification of data occurs during transmission across network. Thus, energy consumed is monitored by current sensor and all the data are recorder and stored in cloud using blockchain. If the overall consumption reaches the threshold value, then it gives notification through android application and the power saving mode will be turned on if still consumption is not reduced. The usage of current, voltage, power and the amount to be paid is sent as message to the user. This system can be used for detecting faulty electrical devices in a household that is consuming unusual amount of power. Also, the user can able to reduce the amount of bill have to be paid.

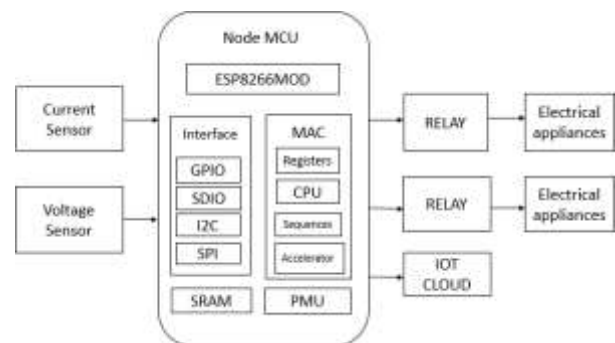


Figure 1: Building blocks of design system

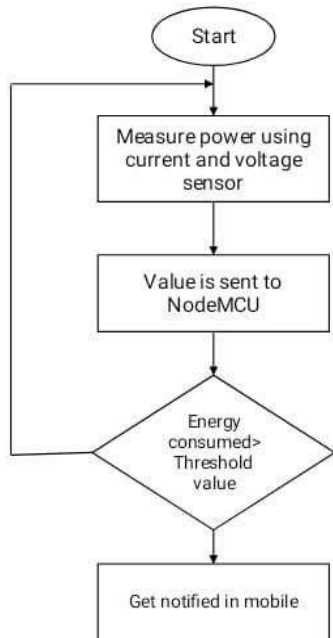


Fig 2: Workflow diagram of monitoring and controlling energy consumption

In Fig 1 shows building blocks of design system. Fig 2 explains how the notification is sent to users. Fig 3 shows how to set threshold value.

1.1. Smart Meter

Smart meter is based on IOT technology and its security is ensured using block chain. The hardware components used in the smart meter are,

- Node MCU
- Current sensor
- Voltage sensor
- Relay
- Power supply

Current and voltage sensor measures the corresponding current and voltage values measured across different loads. It detects the electric current in a wire and it also detects the voltage. The product of voltage and current is the electric power $P=V \times I$.

The unit of electrical energy is given by kilowatt- hour (kWh) which is calculated by multiplying the power used in kW by the number of hours during which the power is consumed. The cost of energy consumed is found by multiplying the value by cost per kWh. Relay is an electromagnetic switch which controls the circuit. In the smart meter, when the energy usage crossed the threshold value, the relay is used to turn off the electrical appliances.

All the loads are connected to detects the through relays which can be controlled by a GPIO pin in detects the. detects the is equipped with an inbuilt WIFI. General Purpose input output (GPIO) pin is a used in an Integrated circuit which is an input or output pin that can be controlled at the run time.

All the values are stored Parallel in cloud. Cloud involves storing of data and it can be accessed anytime, anywhere by any devices over the internet. Here instead of storing values on hard drive, client or the user can directly send files to the data server and that is maintained by cloud provider. The data can be even stored in remote servers and data can be accessed by using cloud.

Twilio is cloud communication platform where the user can register with their login credentials. Through which the user gets notified, if the energy consumption reaches its threshold value. Whereas Cayenne cloud is a broker where the user can check their daily usage.

1.2. Internet of things (IoT):

The internet of things is a system of interrelated and internet connected objects which is able to gather and transfer data over a wireless network such as internet without human intervention. The IoT consist of set sensors and processors which works based on the data collected. For example, the concept of smart city is emerging in multiple continents, where enhanced street lighting controls, public safety, physical security, meter reading, are being deployed on a city-wide scale [7].

Arduino UNO acts as the brain of the system. It is a user-friendly platform. It fetches the data from the sensor and it is processed. The processed data is given to ESP8266. The ESP8266 is a WIFI module which establish the wife connection between cloud and Arduino. The Arduino board can be connected to the system in 3 ways (as shown in Fig 4):

1. USB
2. Jack
3. Battery

The function of Arduino is that it has both physical programmable circuit board which is also known as Microcontroller and software (IDE) which runs on computer.

The purpose of Arduino IDE (Integrated development Environment) is to write and upload the code into Arduino board. And the code used in Arduino IDE is a simplified version for e.g., C++, which is easy to learn.

One of the advantages of Arduino UNO is that it doesn't require any additional programmer/power supply. It is low of cost and it can be operated in any operating system.

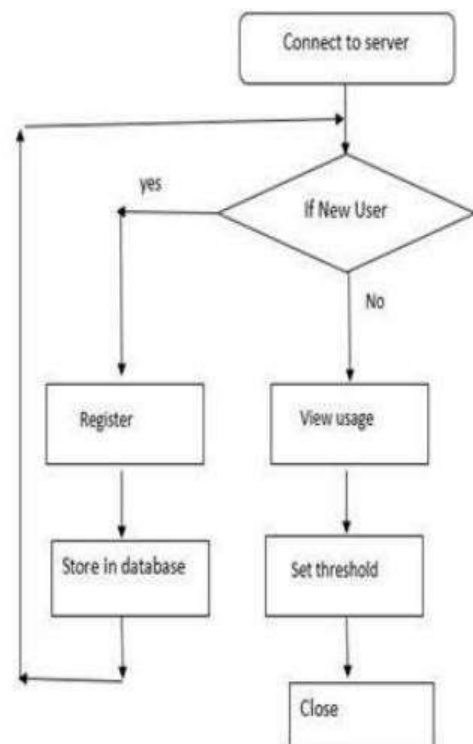


Fig 3: Flowchart diagram of monitoring and controlling energy consumption

1.3. Blockchain

The aim of data aggregation is to reduce the amount of sensitive information which can be disclosed. The privacy-preserving aggregation depend on the cryptographic computation's homomorphic features [9]. Blockchain is the emerging technology, which makes the data transmission secured in the network. In blockchain, the data stored is form of block and each block consist of transmitted data and the cryptographic hash value of the previous block.

The information collected from the smart energy meter is stored in the cloud with the help of blockchain technology. Since each data transmitted is connected to previous block, it is hard for the malicious network to hack or modify the data stored. If any mismatch occurs in the stored data in two different modes, then the data is corrupted. Multichain presents an explanation for organizing personal Blockchains which were assures that the events on the Blockchain may be checked by selected members [5]. The four basic operations in blockchain includes

- It determines the number of participants in blockchain
- It gathers the required data from each participant
- It generates and assigns the block for valid transactions
- Finally, it distributes the corresponding blocks to each participant

BENEFITS:

Manual monitoring of electricity usage from the meter readings is not required. Accurate data is recorded and saved in cloud. Cloud is better than local servers because it is easy to upscale or downscale the amount of space and it doesn't occupy space unnecessarily. Automatic switching from normal mode to switch off or power saver mode is implemented by this system, it is a fully automated system. It can detect any fault loads. Security is also enhanced with the help of blockchain. Economically benefits the consumer by avoiding unnecessary bills on electricity wastage. Use of Android pplication enables easier access.t can monitor each load individually. It is a low power consumption and energy saving system.

EXPERIMENTAL RESULTS:

The experiment is done using single load as well multiple loads. It is experimented using bulbs.



```
Python 3.6.4 Shell
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Block hash: 79a5e7f7377a7d2e1a738e48292e45f56b1c4886c2a4886f94cda4a09
Previous hash: f948e4ac5871abff95e117ab19110a82b73c3f05a8b44726729c1ad1d74
100 2021-03-18 18:51:13
Block Data: current:0.28,voltage:217.34,power:47.33,energy consumed in julies:
47.44,energy consumed in units:0.00
Block hash: f7044ee98f6aac3771d5898b5554e3873e3dda7b7486c46e2238125f3236
Previous hash: 78a5e7f7377a7d2e1a738e48292e45f56b1c4886c2a4886f94cda4a09
100 2021-03-18 18:51:21
Block Data: current:0.28,voltage:217.34,power:47.33,energy consumed in julies:
47.44,energy consumed in units:0.00
Block hash: 72278289a52878a95a156871aac28c7ca790049f7bf8f77b83e88e6e18a77ff
Previous hash: f7044ee98f6aac3771d5898b5554e3873e3dda7b7486c46e2238125f3236
100 2021-03-18 18:51:33
Block Data: current:0.28,voltage:217.34,power:47.33,energy consumed in julies:
47.44,energy consumed in units:0.00
Python 3.6.4 Shell
Permissions: RW  Job: of load: CPU  Trading: OFF 0  Load: 94  Columns: 11  Memory: 52
```

Fig 4: Experimental setup

Power consumed in watt hours by load for every five minutes is shown below, here we have used a 15- watt (night lamp) bulb as load to generate these values, it has consumed approximately 34 watts for one hour. 1 unit is equal to 1000 wathours so according to that we can measure the bill.

Time (hours)	Power (watt hours)
0.05	0.11
0.1	2.78
0.15	5.99
0.2	9.1
0.25	12.13
0.3	14.95
0.35	17.78

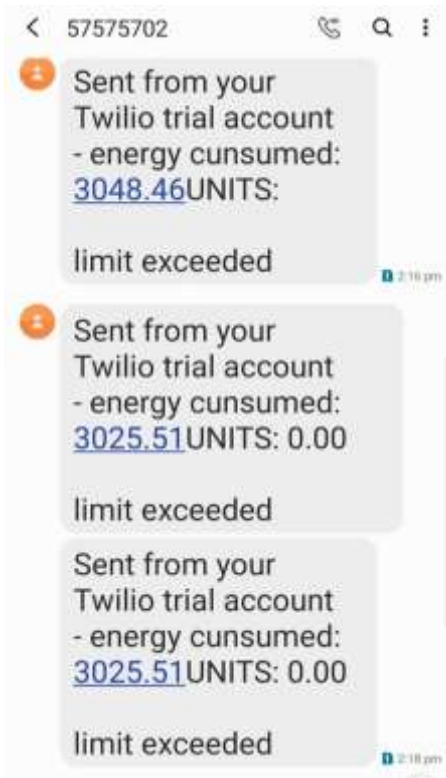


Fig 5: Twilio output

The Fig 5, shown here is the notification triggered via Twilio when the energy consumption exceeds the threshold voltage.

CONCLUSION AND FUTURE SCOPE

In this paper we proposed an idea for monitoring the amount of energy consumed by household electrical devices and controlling the unnecessary loss of electrical energy by combining IoT and Blockchain technologies. It is a secured process since blockchain technology is used. A smart meter which constantly monitors electricity consumed by devices. An android application is used by which the limit value is set by the user. Using the android application, the consumer can also view the total amount of electrical energy consumed by electrical appliances. The user is also provided a notification alert when ninety percentage of the specified threshold value is reached. Using this information, the user may either extend the threshold value or takes precautions to control the electricity. The two reading from the android application and the energy meter is stored in a database using blockchain technology. These values are compared and if the energy consumption exceeds the limit (which is set by the user), the device will be turned off or switched from normal mode to power saving mode. It is also cost effective because very low-cost microcontrollers and sensors are used. Therefore, securing the data using blockchain and storage of consumed power in to the blockchain is also achieved successfully. And in future through bitcoin transactions can be done.

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