Electric Billing System using IoT and Blockchain

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ABSTRACT

Electricity has become an indispensable part of the contemporary lifestyle and we cannot imagine a world without it. Through this project, we aim to raise awareness about the need for a more energy-friendly utilization of electrical appliances to prevent the misuse of energy. Also, it addresses the issue of data security, which has paramount importance in the present scenario. Currently, there exist many methods for meter reading and billing systems. Reading of meters by the officials, and smart meters based on IoT and GSM are some of them but have several disadvantages. Therefore, we put forward a novel idea combining the advantages of cutting-edge technologies like blockchain and IoT, which automates the entire system by providing assured security to the stored data. Blockchain is a decentralized, unalterable platform for recording information that prevents any hacking, or manipulation of stored data. Incorporating blockchain in the project enhances the credibility, transparency, and traceability of the processes, thus making this idea unique. The system we intend to implement enables live status monitoring, provides information regarding the number of units consumed, and facilitates payment. Also, it brings down the dependency on the employers to fetch the reading and thereby minimizes the errors that may arise throughout the process of billing. The advantage of this system is that a user can check the power consumed by the electrical appliances in real-time and can take further steps to control the overuse of energy, thus guaranteeing energy conservation. This project primarily aims at developing a completely automated electric meter billing system that would ensure the complete security of the data.

Keywords: Internet of Things (IoT), Data Security, Energy Meter meter, Block chain

1 Introduction

Electricity is one of the most consequential blessings endowed by modern science which plays a significant role in the day-to-day life of mankind. In this well-advanced life, one cannot imagine a world without electricity. From homes to huge factories around the globe, every device, and machine operates with electrical energy. A device, known as the electric meter is used for the continuous monitoring and measurement of electricity being consumed. This device facilitates the easy calculation of the electricity consumed by a domestic building, a factory, or an electrically powered device. Recent statistics prove the rapid increase in the consumption of electrical energy. Currently, there exist several methods to carry out the meter reading and billing processes. Most common among them is the manual reading of the meter by the officials from the authorized department where the concerned official visits every home or industry and manually carries out the calculation or estimation of the bill consumed by a consumer and sends it to them. The crucial disadvantages of this method are the high chances of errors as there is human intervention in the processes leading to the lack of integrity and credibility and also the wastage of money and workforce as a large number of employees are involved in the process. Smart meters [5], [2] utilizing technologies like GSM and IoT [3] are the other methods used for energy meters' reading and billing purposes. This method is widely used and is highly dependable which overcame most of the drawbacks of the manual practice, but the major disadvantage of this system is that storage of data is done on a common cloud which is centralized so there may be chances for any external involvement leading to the hacking of the system and the

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manipulation of the data. Thus inadequacy of the assured security of the stored data is of greater concern in these methods. Thus we put forward a completely automated electric billing system that utilizes all the benefits of modern technologies. Through this project, we aim to raise awareness about the need for a more energy-friendly utilization of electrical appliances to prevent the misuse of energy. Also, it addresses the issue of data security, which is of paramount importance in the present scenario. The system can provide information on the consumption of each unit of energy and also helps to calculate the electric meter reading using the benefits of IoT and blockchain. IoT and blockchain [6] are two upcoming technologies that have numerous benefits. They help to automate the entire system and to provide transparency and security [8] to the entire stored data. By implementing this idea, human reliance on acquiring the meter reading and the billing errors that may arise due to human involvement can be minimized to a great extent. In addition to being able to continuously monitor the energy used by household appliances in real-time, the user can also adopt appropriate methods to prevent overuse and waste of energy, which facilitates the conservation of electricity as a result.

2 Experimental Procedure

We intend to implement a completely automated electric meter reading billing system [2] using IoT and Blockchain. The system consists of mainly two sections;

1) A hardware section comprising the IoT devices [4] that need to be implemented in the houses.
2) Software section which is the blockchain.

2.1 Block Diagram

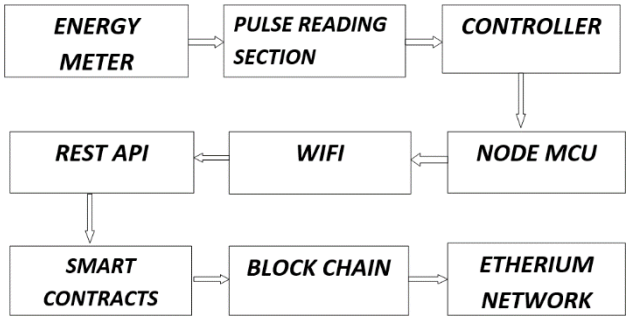

Figure 1: *Block Diagram*

The working of the proposed smart meter is depicted using a block diagram shown in Figure 1. The smart meter estimates the quantity of electricity used and uploads it to the cloud, from where the concerned person can see the number of units consumed per day. Thus it facilitates live status monitoring of energy consumption. The provision to develop and analyze the daily utilization report is also provided with the help of an online portal. This idea reduces the deploy- ment of manpower for taking meter readings and distributing bills. Blockchain, especially Ethereum [8] involved in the technique ensures complete security to the transferred and stored data, and hence incorporating blockchain [6] enhances the credibility, transparency, and traceability of the entire processes. The components used for the designing of the system are shown in Figure 1. Thus we could develop a transparent, immutable, and highly scalable system that helps to calculate the electric meter reading without human involvement.

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2.2 Components and Working

2.2.1 Energy Meter

The energy meter shown in Figure 2, which is a measuring device is used to monitor and calculate the quantity of electricity consumed over a while. Single phase electric meter as shown in Figure 2 is used for this project. This is the primary required component of the proposed system from which the readings are taken as the inputs for generating the bills and for enabling live status monitoring through the website.

Figure 2: *Energy Meter*

2.2.2 Pulse Reading Section

The pulse Reading section used in the proposed system is shown in Figure 3. It is a circuit with an optocoupler. The semiconductor device known as the optocoupler also called the optoisolator is used to provide isolation to the circuit. It consists of two parts: an LED that is turned on by receiving the signal from the energy meter and a photosensitive device or phototransistor that operates by receiving visible light from the LED. A black box with connective pins as illustrated in Figure 2, holds both of these components.

Figure 3: *Pulse Reading Section*

2.2.3 NodeMCU

NodeMCU shown in Figure 4, is a wi-fi-based, easily accessible board that can be used for many IoT applications. This microcontroller is easily available at a very low cost. Its ability to operate at low power and its compatibility with the Arduino programming language enhance its popularity in these types of IoT- based projects [1], [7]. In this project the 7805- voltage regulator connected to the Vin pin is used to power the microcontroller. This is programmed in such a way that the readings from the meter and the pulse reading section connected to the D0 or 30th pin are counted and considered as input. The 5V relay module connected to the D1 pin that turns on and off an ac, supply is used

to control AC equipment. The data is then transferred using the WiFi of the nodeMCU and stored in the Blockchain.

Figure 4: *Node MCU*

2.3 Circuit Diagram

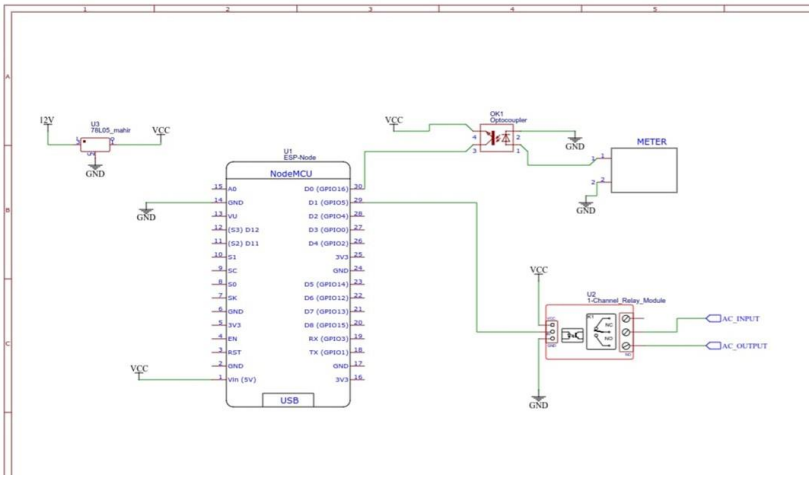

Figure 5: *Circuit Diagram*

The circuit diagram as illustrated in Figure 5, includes an ESP8266 Node MCU, Voltage regulator, single-phase energy meter, an optocoupler, and a relay. Figure 5, clearly describes the components used for the development of the circuit and it's working. In this hardware section, the 7805 Voltage Regulator is used which converts the 12V input supply to 5V, which is the Vcc, given as input to the Node MCU.ESP8266 Node MCU, the IoT platform used, is this work's main hardware component. Vcc is connected to the Vin pin of the Node MCU and all ground pins are given as common. D0 and D1 are the general-purpose input-output pins used for connecting the relay and the electric meter part. At the 30th pin(D0), the output signals from the meter reach the Node MCU through the optocoupler circuit. Optocoupler is used mainly to provide isolation to the circuit. At the D1 pin, the relay is connected which turns ON and OFF the electrical devices. The relay is maintained in the ON condition whenever the D1 pin is high. The Node MCU is programmed in such a way that until the maximum limit of pre-determined current usage is reached, the D1 pin is maintained in the HIGH position so that the relay and the home appliances are in ON condition. When the maximum limit of current usage reaches, D1 becomes LOW, and thereby relay is turned OFF which leads to the automatic shutting down of devices.

3 Final Hardware

The final hardware of the proposed system is depicted in Figure 6. The compo- nents used for the

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development of the hardware section of the system are clearly visible in Figure 6.

Figure 6: *Final Hardware*

4 Results and Discussion

We conducted an experiment to analyze and verify the working of our software system utilizing the platform named Remix IDE. Remix IDE allows the de- velopment, deploying, and administering of smart contracts for Ethereum-like blockchains [8]. Below are the features provided in the software section of the project:

1) Install the REMIX IDE application on your device as shown in Figure 7.

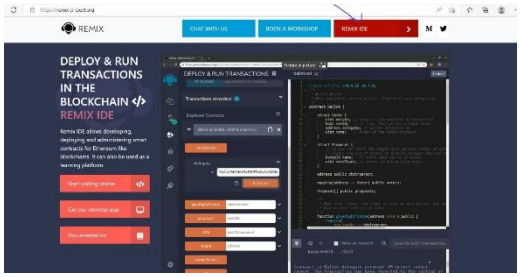

Figure 7: *Login page*

2) The features to be executed are already written using the smart contract(saved as main.sol in this example) which is deployed in the blockchain Ethereum network as shown in Figure 8.

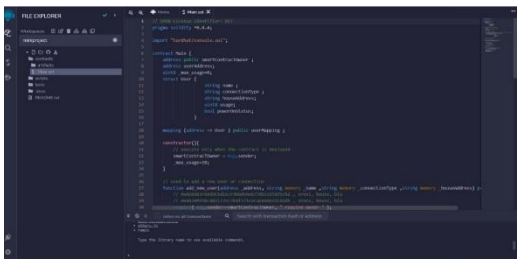

Figure 8: *Smart Contract-main.sol*

3) Provisions for adding new users, paying a bill online, monitoring of con- sumption of electricity, user mapping, etc. are provided. This deployed smart contract is shown in Figure 9.

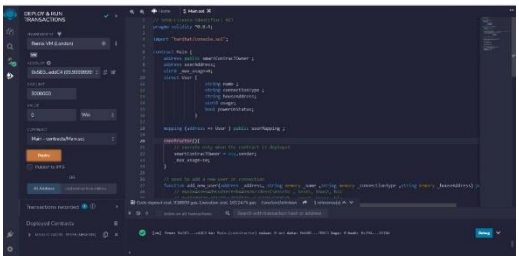

Figure 9: *Deployed Smart Contract and the features included*

4) In the "add new user" icon, the owner can add the details of all the users such as name, connection type, address, etc. This feature of adding the details of a new user is depicted in Figure 10.

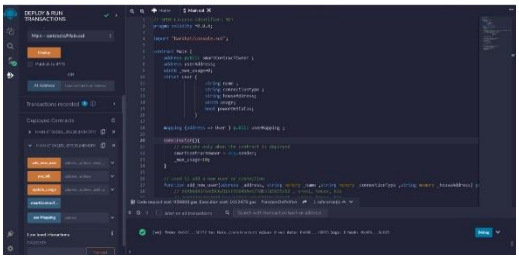

Figure 10: *Addition of the details of the new user*

5) Once these details of the user are added and transacted, the user can view these details including his updated daily consumption of electricity in the" usermapping" icon from anywhere in the world through this application, which is shown in Figure 11.

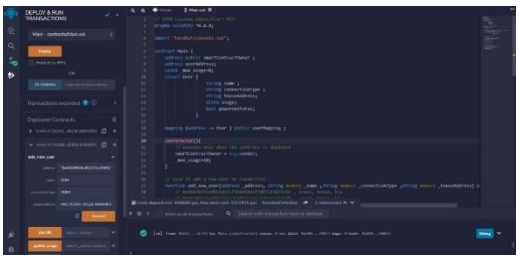

Figure 11: *User Mapping*

6) We can set the maximum usage limit in the application. Once the usage of electricity reaches the maximum value, "power on status" becomes false and it leads to automatic disconnection of the supply which is depicted in Figure 12.

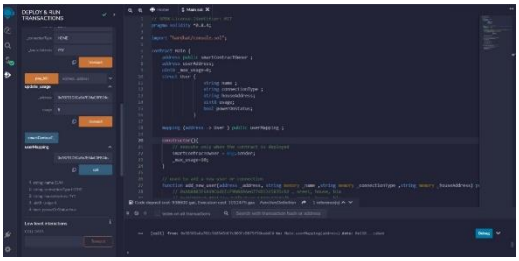

Figure 12: *Setting up the Maximum Usage Limit*

7) Provision to pay the bill via an online mode is provided in the "pay bill" icon which is depicted in Figure 13.

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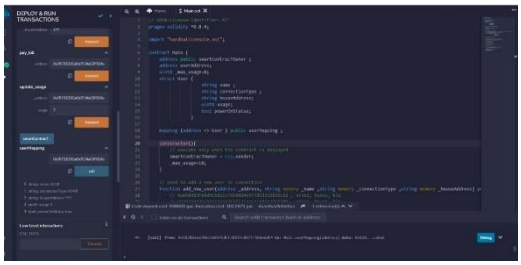

Figure 13: *Bill Payment*

8) Once you have successfully paid the bill the supply will be reconnected and the usage value will be automatically adjusted to zero and the updated daily usage will be displayed as before.
9) It real-time monitors the usage & sends data on real-time to the user so that the user gets updated on the consumption of electricity and measures can be taken to prevent over usage. The output screenshots after executing the project in the platform performing various functions are given below:

Finally, the website is developed using React.js, an open-source javascript framework widely used to build up User Interfaces (UI) and web applications rapidly. The UI developed for this proposed system is illustrated in Figure 14. The authorized user can log in to the website only after providing the corresponding password as depicted in Fig 15. The officials of the concerned authority will be the owner of this platform and any changes, additions, or alterations in the stored data can be made by the administrators only. Payments can also be made through this platform which is shown in Fig 16. The changes that occur on the website after payment are shown in Figure 17. Therefore using blockchain and metamask, the security of the stored data can be assured completely. The UI, login page, and payment page of the website are shown in the below screenshots.

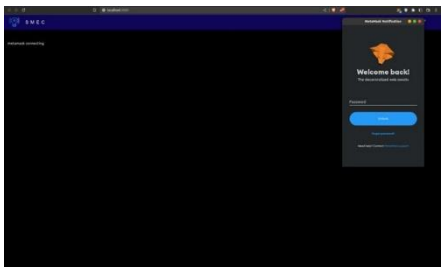

Figure14: *UI*

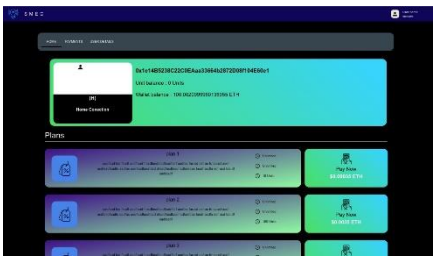

Figure 15: *Login Page*

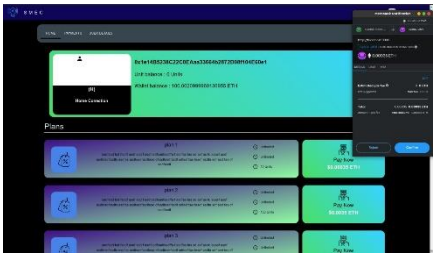

Figure 16: *Payment*

Figure17: *After Payment*

5 Conclusion

This idea of an Electric billing system using IoT and blockchain brings forth a new credible method for reading and billing electric meters. As this method utilizes the benefits of modern pioneering technologies such as blockchain and IoT, the advantages and features it can offer are far more than the currently existing methods. As no human involvement is essential for meter reading and billing purposes, it ensures error-free and transparent measurements and thus overcomes the drawbacks of existing methods. As the data stored in the Ethereum blockchain networks are immutable [6], it is impossible to hack and this ensures the credibility and transparency of the system. This method is highly scalable and can be decentralized effectively. Thus the proposed idea is an innovative solution to the issues faced in the electric billing sector and can be implemented effortlessly and effectively shortly. In this modern world of numerous technologies, digitizing and utilizing technologies in the meter reading and billing system is highly acceptable and profitable. Thus we hope to develop a fully automated meter reading and billing system that assures the complete security of the data.

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