Smart Meter using Blockchain

Romal Raju
Department of CSE
College of Engineering Kidangoor
Kottayam,Kerala,India
romalraju124@gmail.com

Sandra Madhu
Department of CSE
College of Engineering Kidangoor
Kottayam,Kerala,India
sandra99madhu@gmail.com

Athulya T S
Department of CSE
College of Engineering Kidangoor
Kottayam,Kerala,India
tsathulya78@gmail.com

Mrs.Rekha KS
Assistant Professor
Department of CSE
College of Engineering Kidangoor
Kottayam,Kerala,India
rekhaks@ce-kgr.org

Aparna Unni
Department of CSE
College of Engineering Kidangoor
Kottayam,Kerala,India
aparnaunni28@gmail.com

***Abstract*— Smart Meters are considered one of the most advanced technologies in the smart grid due to both communication and real time monitoring. Smart meters provide energy saving and cost effective control of the grid. With the help of our smart meter the service providers can sort the data of each location efficiently and get a early prediction of additional current to be supplied. Our project is proposed to create an automated device that can record the amount of energy consumed and its equivalent electric charge, store it in a blockchain , make payment through crypto currency. The personal information collected in real time is alarming, as it may lead to violation of users privacy. In this scenario we employ the blockchain technology. Our smart meter provide features such as in-built fire, flood, gas detectors, thus provide better security to devices and household. Smart meter also provide a home automation system, which includes a voice assistant (like Alexa, Google home etc..) to control smart appliances, with an additional feature to control electronic devices wirelessly through a mobile application. The smart meter will automatically adjust the cooling appliances (fan, AC, etc..) according to the temperature and by detecting the use of light in the environment, it automatically turns on when the environment is dark and turns off when it receives light.**

Keywords— Smart Meter, Blockchain, Arduino, NodeMCU

I. INTRODUCTION

Electricity has become inevitable part of life as it is important for today's life because it is used in daily life products such as computers, televisions and telephones, as well as commercial buildings ,workplaces ,internet etc. Today almost all the buildings have electromechanical watt-hour meters. Electromechanical watt-hour meter is a device that measures and records the amount of electrical energy flowing through an electrical outlet over time. The readings are recorded manually by the service provider in regular intervals, but there is a high dance of alteration in reading and bill payment. Our project is proposed to create an automated device that can record the amount of energy consumed and its equivalent electric charge, store it in a blockchain (Ethereum network), display the amount in our app and make payment through crypto currency (Ether) with the help of meta mask wallet. Meta mask as the One of the top-rated crypto wallets for Ethereum is known for its user-friendly interface, which offers swift and effortless access to numerous tokens and decentralized features. applications on the Ethereum network. The individual information collected in real-time is the issue of concern, as it may lead to violation of users privacy, In this scenario we employ the blockchain technology. The use of blockchain enable us to decentralize the existing centralized system of energy management. In addition smart meter can guarantee better user experience compared to traditional electromechanical watt meter. Smart meters provide an energy-efficient and cost-effective solution for managing an electrical grid.With the help of our smart meter the service providers can sort the data of each location efficiently and get a early prediction of additional current to be supplied. Our smart meter provide features such as in-built fire, flood, gas detectors, thus provide better security to devices and household. For the fire detector the IR Flame sensor is used, for flood detection, SEN18 Water Level Sensor and for LPG leakage, MQ3 LPG Natural Go Sensor Module is used. Smart meter also provide a home automation system, which includes a voice assistant (like Alexa, Google home etc..) to control smart appliances, with an additional feature to control electronic devices wirelessly through a mobile application. The voice assistant mainly

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requires a NodeMCU 8266 and a Relay Board as its hardware component and python for giving necessary instructions. The smart meter will automatically adjust the cooling appliances (fan, AC, etc..) according to the temperature and by sensing the use of light in the environment, it can automatically turn on when the environment is dark and turn off when it gets light. For creating this system Arduino UNO and LM35 Temperature Sensor and LDR 5mm Light Sensor is required.

II. LITERATURE REVIEW

A. Smart Grid

1. The smart grid is a modern system that combines cyber and physical elements to create a platform for efficient communication, management, and monitoring of energy consumption and information flow[1]. Its functions are not limited to energy management but also encompass information exchange. This unique system utilizes advanced metering infrastructure (AMI) to gather and analyze data from smart meters, which are capable of supporting various functions beyond just recording energy usage, such as load and cost management for the utility[2]. The Smart Grid is a blend of new and existing technologies that work together to enhance energy efficiency, reduce costs, and improve product quality and reliability[3]. Because data management is vital to the Smart Grid's operations, it employs a Meter Information Administration Framework to store and manage data[3]. The communication structure of the Smart Grid is complex, requiring a reliable and well-integrated infrastructure to function effectively. With bi-directional power and data flow connections, the Smart Grid is designed to automatically control energy consumption and facilitate consumer participation[3].

B. Smart Meter

A smart meter is an advanced energy meter equipped with smart technology that enables it to measure electrical energy consumption, in contrast to traditional meters. They are highly efficient devices that fundamentally transform the operation of power networks[3]. Besides their primary function as a meter, smart meters can also serve as sensors throughout the distribution network. With the Advanced Metering Infrastructure (AMI), smart meters can measure and record actual energy consumption over days at specific time intervals. The data collected is transmitted via a secure radio network to the central data management system. In India, the implementation of smart meters is still in its infancy stage, but many developed countries such as Australia, Canada, the USA, and the UK have already implemented smart meters on a large scale[4]. By regularly monitoring and analyzing smart meter data, utilities can obtain customer-specific energy consumption trends, allowing them to pre-program enough power. Smart meters also form an essential component of smart homes, facilitating in-house energy management[4]. Additionally, they enable utilities to plan, operate, and respond faster to network outages. These meters also permit the expanded determination of information on various measurement parameters over the system, which can be utilized by utilities for the following applications[4]:

a. Provides timely data to field operations for faster error detection, response, and recovery.

b. Enables utilities to better inform customers about the status of the power grid. They can communicate pertinent information such as the reason for the outage, expected recovery time, and public safety notices.

c. Improves the accuracy of network asset scheduling and management to improve fault tolerance, reduce potential downtime, and reduce the frequency and duration of outages.

C. Internet Of Things(IOT)

The Internet of Things (IoT) refers to the interconnectedness of physical devices that generate vast amounts of data on a daily basis. This data can be stored either on the cloud or on a local server, with the former being the preferred solution due to its scalability and communication capabilities. However, storing data on the cloud can lead to security issues and cyberattacks, and conventional security measures can be both expensive and vulnerable to attack. Moreover, the data generated by IoT devices is often noisy and raises concerns about user privacy. To address these challenges, new technologies are needed that can provide better security and privacy. Ensuring the security of such a large amount of data is a major challenge, particularly when it comes to the security issues that arise with IoT devices. Each node in an IoT network is vulnerable to attack, including Distributed Denial of Service (DDoS) attacks that overload the node with traffic in an attempt to crash it. Additionally, the centralized nature of IoT servers makes them easy targets for attackers, and confidentiality, authentication, and data integrity are significant challenges that need to be addressed.

D. Security

Smart meters are delivering data to utilities more often than ever. This information contains huge sums of private data.Information is transmitted to the utility company through, regularly employing a remote medium.Securing client protection and keeping up the secrecy of information are essential duties of utilities in a savvy lattice environment. The utilities try to protect this data to the best of their abilities by using various encryption techniques. Based on past experiences with the web, it is evident that there is an ongoing conflict between hackers and security measures. By analyzing frequent data, a strong correlation between control usage and user behavior can be established [5]. For instance, based on the amount of control usage, one can accurately predict the user's presence in their premises. Unfortunately, this has resulted in a negative perception of smart metering. [5].

E. Blockchain

Blockchain is an ever-growing, secure, shared recordkeeping framework in which each client of the information holds a duplicate of the records,which can as it were be upgraded in case all parties included in a exchange concur to overhaul. In blockchain technology, every transaction is recorded in a block on the network. Each block, similar to a chain structure, contains the hash value of the preceding block, creating a secure and immutable ledger of transactions in BC.. This structure advance makes unchanging nature[6].Any change in BC can be reported using a block signature, the change is then verified by network users. BC uses a different consensus algorithm to identify transactions. The consensus algorithm is the consensus Within a network or community, a group of individuals are responsible for validating transactions. At the end of the approval process, it was determined by a majority of votes. Zys kind et al. [7] used blockchain to supply dispersed individual information administration and guarantee protection as well. Blockchain is used as an automatic access controller, so no one else needs to do it. Only address information is stored in the blockchain and distributed hash is used to identify the stored information. This reduces the risk of data breaches.

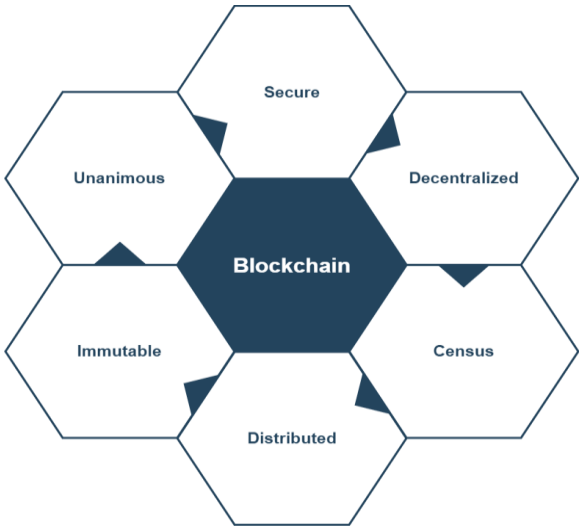

Fig. 1. Features of Blockchain[Google]

The Approval Algorithm (CA) is employed to obtain validation for specific requests within a distributed system. CAs are utilized to create a BC system that operates without the need for trust among parties. The consensus algorithm is utilized by the processing nodes to generate blocks. Smart contracts are self-executing scripts that manage data. A generated block consists of a header and a body block[8]. The block header includes elements such as the current number, address of the previous block, destination of the current block, Merkle root, anonymity, and timestamp. The body block has modifications that vary in application area. It is crucial to have an accurate and reliable header content to create a block header. The hash of the previous block is a 32-bit long string used for chaining links to previous or parent blocks. The nonce is a 4-byte long value that miners use to generate variables and produce correct hashes in an array. The timestamp enables viewing the recorded data of a specific event, and it usually provides the creation date and time of the block and is 4 bytes long. The Merkle root is a 32-bit long string that contains all the hashed transactions within a hashed transaction[9]. In blockchain-based cryptocurrencies, each block has an associated hash value that makes it challenging to manage transactions. The nodes of the blockchain P2P network commonly use a consensus process to validate information[9]. There are various consensus protocols used for different types of blockchain. The most commonly used consensus protocol in blockchain-based cryptocurrencies is Proof-of-Work (PoW). Major blockchains like Bitcoin and Ethereum use different versions of the PoW protocol[10]. In the PoW protocol, each node competes to find a value that generates a hash satisfying certain conditions. The complexity of calculating such a zero value is determined based on hashing the values. Blocks are created and announced to the P2P network when there is such an inconsistency.

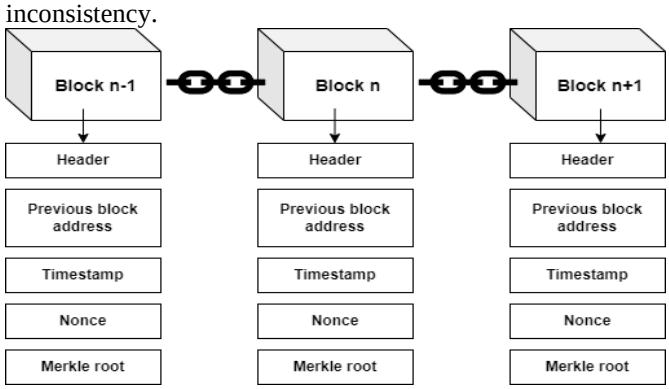

Fig. 2. Structure of Blockchain [Google]

F. Arduino UNO

Arduino UNO is a durable and user-friendly microcontroller that is based on the ATmega328P processor. It features 14 input/output ports, with 6 of them supporting Pulse Width Modulation (PWM) operation. Additionally, the board includes transmit and collector ports that can be used for serial communication with other devices. There are three ground ports and one 5V output power port, along with a 16 MHz quartz crystal, a 5V power jack, an ICSP header, a 32KB flash memory, and a reset button. These devices can be easily monitored and controlled from anywhere in the world, making them suitable for a wide range of applications. Fire has been a hazard to property and people for centuries. The extinguishes fires far more effectively than conventional methods. The Automatic Fire Suppression System is a standalone and is implemented using The components needed for this system are readily available. In typical circumstances, the system will designate rooms as safe.

Additional contributions to the research include the design of the Arduino Algorithm and sensor placement calculations to ensure the system runs efficiently and effectively in all situations, as well as an ideal backup power source in case of emergency power loss. The fire suppression component displayed could be a self-checking system that detects the presence of fire through a particular wavelength range and extinguishes the fire by dispersing water through multiple sprinkler heads [11]. The controlling unit used for the fire suppression component is an Arduino Uno. One major advantage of this system is its ability to quickly detect fire and run water through dedicated channels using a solenoid valve. Fire is a catastrophic event that can cause a significant loss of property, human life, and confidential facilities. To prevent such losses, various suppression systems have already been developed, such as sprinkler heads with temperature-sensitive valves and temperature sensor-based systems. However, these systems have a high chance of delayed detection and human error, which can mislead the detection and the entire system[12].

The fire suppression system, on the other hand, is extremely well-designed and has no chance of human error because it is completely self-sufficient. The room or area will have dedicated overhead sprinklers connected to the water supply through its dedicated solenoid valve, which controls the flow of water in pipelines. The triggering devices of this system are the fire sensors, which, when they detect a fire, will activate an alarm. The algorithm set in the Arduino will come into effect, and an ideal voltage will be given to the solenoid valve through a relay. As a result, water will immediately surge out of the sprinklers to extinguish the fire. The sensors used are very sensitive before reaching the point of interest [13]. The system has also been tested to extinguish a fire at full scale. Our Automatic Fire Suppression System can be used in both commercial and private applications.In the control unit of the system, pin 7 is used to receive a signal from the NAND gate (HD74HC20). Four flame sensors continuously check for traces of flame. If a flame is not detected, the output is 1, and if a flame is detected, the output is 0. The sensor output is fed into a 4-input NAND gate. The output of the NAND gate is 1 when one of the four flame sensors detects a flame (e). The relay is then switched using pin 13 as a digital output [14]. Also, on pin 13, a buzzer and transistor (BC547) are connected through a 1k resistor, and similarly, an LED is connected through a 1k resistor. Their purpose is to specify a period during which the relay is on. Two 12V, 20Ah batteries in the series are connected in parallel to a 24V solenoid valve through a protection circuit and relay[15]. The protection circuit consists of 0.1uF capacitors and diodes. The counter electromotive force generated inside the coil of the solenoid valve is suppressed. A 24V to 5V buck regulator is used to power the Arduino from the battery.

G. NodeMcu

NodeMcu is an open-source extension of the ESP8266 WiFi module, which simplifies networking for IoT applications. It provides a comprehensive API using Lua scripts for hardware IO, which reduces development time and eliminates wasted effort. NodeMcu allows you to easily program the ESP8266 WiFi module using the powerful and user-friendly LUA programming language or the Arduino IDE. The board includes 16 digital input/output ports, two of which are dedicated transmit and receive pins for serial communication. It also has three grounding ports and one Vin port for power.

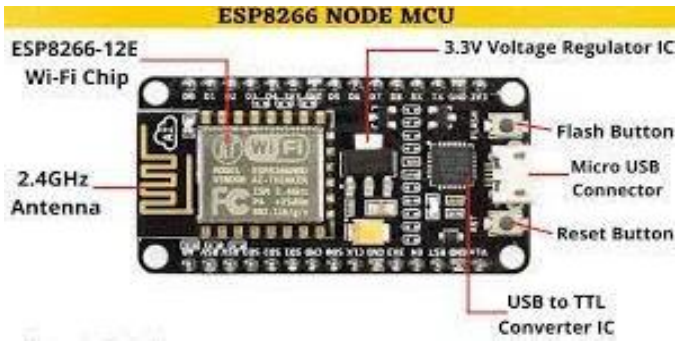

Fig. 4. NodeMcu[Google]

H. Relay Board

Relays are specialized switches that have the ability to control electrical circuits either electromechanically or electrically. They operate in either an Ordinarily Open (NO) or Ordinarily Closed (NC) state, depending on whether the circuit is open or closed, which determines the current passing through the circuit when it opens or closes. The state of the relay changes when a small current is applied, allowing a small current to control a larger one. Relays are commonly used to turn generators on/off, and advanced versions can protect the generator from faults and shutdowns by managing and controlling its current distribution. The use of an 8-channel relay board provides control over multiple devices.

III. COMPARATATIVE STUDY

I. Benefits of smart meter

The use of smart metering provides a multitude of advantages to consumers, utilities, and society as a whole : Benefits to consumers include receiving more information about their energy usage, which can improve energy efficiency for both individuals and industries, as well as receiving detailed reports on delivery quality and energy usage. In addition, invoices are based on actual consumption, allowing customers to lower their electricity bills by changing their habits and using energy during non-peak hours. Power outages are also reduced, and switching or moving becomes an easy process. Furthermore, the need for invoice evaluation is reduced.Utilities also benefit from smart

metering, as demand peaks are reduced and remote management allows for better management of billing and other consumer-related issues. Automatic and remote meter reading improves the efficiency of the electrical system and enables dynamic pricing. Smart meters also play an important role in the development of the smart grid and optimize income from existing resources while reducing operating costs.Finally, the environment benefits from the use of smart meters, as they communicate directly with the utility, eliminating the need to park utility trucks on the street. Additionally, smart meters appropriately allocate existing power consumption, which reduces the need for new power plants and subsequently reduces environmental pollution.

Feature	Traditional meter	Smart meter
Power generation	Centralized	Distributed
Power consumption	No influence of consumers over management	Consumers can manage and control grids
Communication	One-way	Fully two-way
Operation	Manual monitoring	Remote real-time monitoring
Power sources	Non-renewable sources	Renewable sources
Metering	Electromechanical	Android monitoring
Operation cost	Very high	Low because of distributed systems
Transmission and distribution	Consumers cannot receive updates	Regular, accurate, and fast energy

Fig. 5. Traditional meters and Smart meters

IV. CONCLUSION

The Blockchain enabled smart meter provides better security user experience to the user to develop a device that measures the electrical energy consumption of electronic equipments in houses, stores data (kilowatt hours) in blockchain and provides the bill directly to the user through a mobile application. Users can use cryptocurrency to pay their bills on a regular basis. This project is proposed to create an automated device that can record the amount of energy consumed and its equivalent electric charge, store it in a blockchain (Ethereum network), display the amount in our app and make payment through crypto currency (Ether) with the help of meta mask wallet. The concern lies in the real-time collection of personal data, as it may lead to violation of users privacy. In this scenario we employ the blockchain technology. It also displays information such as consumption of electric energy, voltage levels, during short intervals in the app. It provides additional features such as fire, flood, gas detectors to ensure the security of house as well as the devices in it. Our smart meter also provides a voice enabled home automation, temperature based fan control, and an automatic night light system.

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