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Peer 2 Peer Energy Trading using Blockchain and IoT

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Abstract: *IoT integration and blockchain technologies have created new opportunities in energy management. Peer-to-peer (P2P) energy trading is made possible by this study's innovative framework, which uses blockchain and IoT to provide direct energy exchange amongst prosumers in a decentralised network. IoT devices offer real-time monitoring, while blockchain makes sure that transactions are transparent and secure. Transaction costs are decreased via smart contracts, which automate the process. Our experiments in the real world and simulations show better resource use, lower carbon foot-prints, and more consumer autonomy. This framework encourages innovative energy management practices and sustainable energy systems.*

Keywords: Blockchain, Decentralisation, Energy Trading, Internet of Things, Peer-to-peer, Smart Contracts

I. INTRODUCTION

The growing needs for decentralisation, sustainability, and resilience are causing a fundamental shift in the global energy sector. In order to address these changing needs, traditional energy distribution strategies, which are typified by centralised generation and one-way transmission, are finding it increasingly difficult. Peer-to-peer (P2P) energy trading has garnered significant attention as a viable alter-native paradigm that enables individuals and communities to engage in the energy market. Blockchain technology and Internet of Things (IoT) convergence has become a disruptive force in many industries, opening up new opportunities for transparent and decentralised systems. IoT device and blockchain integration has a lot of potential to enable safe, reliable, and efficient peer-to-peer energy trans-actions in the context of energy management. There is a lot of promise for facilitating safe, reliable, and trustless peer-to-peer energy transfers through the integration of blockchain technology and IoT devices. Through the utilisation of IoT sensors, actuators, and communication capabilities in conjunction with the dis-tributed and unchangeable ledger offered by blockchain technology, it becomes possible to create a decentralised energy marketplace in which prosumers and consumers can engage in peer-to-peer direct exchanges of excess energy. This study uses blockchain and Internet of Things to propose a comprehensive architecture for peer-to-peer (P2P) energy transfer. Using decentralisation, automation, and cryptographic security, we want to overcome the drawbacks of conventional energy distribution systems, including their inefficiencies, lack of transparency, and reliance on centralised middlemen. Our suggested approach ensures integrity, openness, and ease of energy trading between users in a decentralised network.

The rest of this essay is structured as follows: Section 2 presents a synopsis of relevant research in the area of peer-to-peer energy trading, emphasising current strategies, obstacles, and prospects. The architecture and design concepts of our suggested system are presented in Section 3, along with a list of its main parts, features, and functions. In Section 4, we go into the specifics of how blockchain technology is implemented and how IoT integration works, explaining how these technologies combine to make P2P energy transactions safe and effective. To illustrate the viability and efficacy of our strategy, Section 5 provides experi-mental data together with a description of the evaluation process. The work is finally brought to a close in Section 6 with an overview of the contributions, pos-sible uses, and future research prospects.

II. PROBLEM STATEMENT

A. Problem Statement

Because of their one-way transmission and centralised control, traditional energy distribution systems are inefficient and waste money. In the energy market, disagreements, hold-ups, and inefficiencies are caused by a lack of trust and open-ness in energy transactions. Existing energy grids run the risk of being physically or cyberattacked, which compromises the security and dependability of electrici-ty delivery. Adoption of sustainable energy sources is hampered by obstacles to appropriate pay and market entrance for small-scale renewable energy producers. Subpar resource utilisation results from consumers' frequent lack of autonomy and flexibility in controlling their energy output and consumption.

The impact of current peer-to-peer energy trading systems on the larger energy ecosystem is restricted due to their low scalability, interoperability, and user uptake. Innovative energy trading methods and technologies are hindered by the integration of antiquated and inflexible regulatory frameworks and market struc-tures.

In underprivileged communities, energy poverty is still a major problem that is made worse by a lack of inexpensive and dependable energy services. Environ-mental issues like pollution and carbon emissions are getting worse, so we need to move quickly to switch to greener, more sustainable energy sources. In the face of shifting energy demands and obstacles, community empowerment, crea-tivity, and resilience are hampered by the centralised form of energy governance and decision-making.

B. Objectives

- To build an IOT-based solar module-based auto-fetch data platform:
- By incorporating IoT sensors and technology into solar panels, it is possible to create an auto-fetch data platform that uses an IoT-based solar module to auto-matically collect and transmit different types of data.
- To design a website that manufacturers and consumers may both access:
- Building a platform that meets the requirements of both user groups is neces-sary to create a website that is accessible to producers and consumers alike.
- To establish a system that allows energy to be seamlessly transferred from producer to consumer:
- The establishment of an energy transfer ecosystem that is seamless requires the integration of multiple technologies and components in order to enable the efficient movement of energy from producers to consumers.

III. METHADOLOGY

Peer-to-peer (P2P) energy trading is a promising way to optimise energy distribu-tion and utilisation in the shift to sustainable energy systems. This paper de-scribes a process for integrating an ESP32 microcontroller into a peer-to-peer energy trading system to enable single cycle energy transfer between two house-holds. Coloured bulbs and a terminal display are two examples of the visual rep-resentations used by the system architecture to show the energy transfer process in real time. This technique intends to demonstrate the viability of real-time en-ergy exchange in P2P energy systems and offer insights into the dynamics of en-ergy trade by outlining the system architecture, implementation methods, and testing methodologies.

IV. SYSTEM DESIGN AND EXECUTION

An ESP32 microcontroller is used in the single cycle energy transfer system to enable energy trading between two residences, symbolised by lightbulbs. In this configuration, House 2, represented by a green bulb, has excess energy, whereas House 1, represented by a blue bulb, is energy-deficient. The ESP32, the system's central component, controls communication and directs the energy transfer pro-cedure. The ESP32 microcontroller, two coloured bulbs (blue for House 1 and green for House 2), and a dependable power source are examples of hardware components. The Arduino IDE is used to implement the software, enabling the ESP32 to be programmed to manage real-time updates and energy transfer logic. The ESP32 is initially set up to create connections between the two residences and regulate the lighting of the bulbs. The programming of the ESP32 implements the logic for a one-time transfer of 69 units of energy from

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House 2 to House 1. A terminal interface that is configured to show energy metre readings is another feature of the system that gives users immediate feedback on the energy usage of both homes before and after the transfer. To ensure the correctness of the transfer process and to monitor the flow of energy, this terminal display is essential.

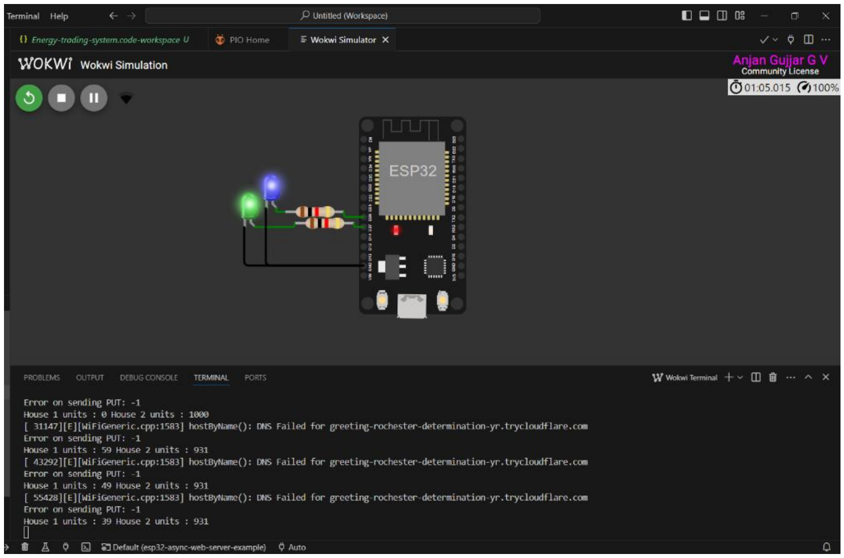

Fig. 1 ESP32-Based Energy Transfer between Houses

V. IMPLEMENTATION, EXAMINING AND VERIFYING

House 1 starts the energy transfer process by emulating a buy request to House 2 for 69 units of energy. In order to fulfil this request, the ESP32 transfers the designated energy units in a single cycle. The terminal adjusts in real-time to represent the shifting energy levels of both households as the transfer takes place.

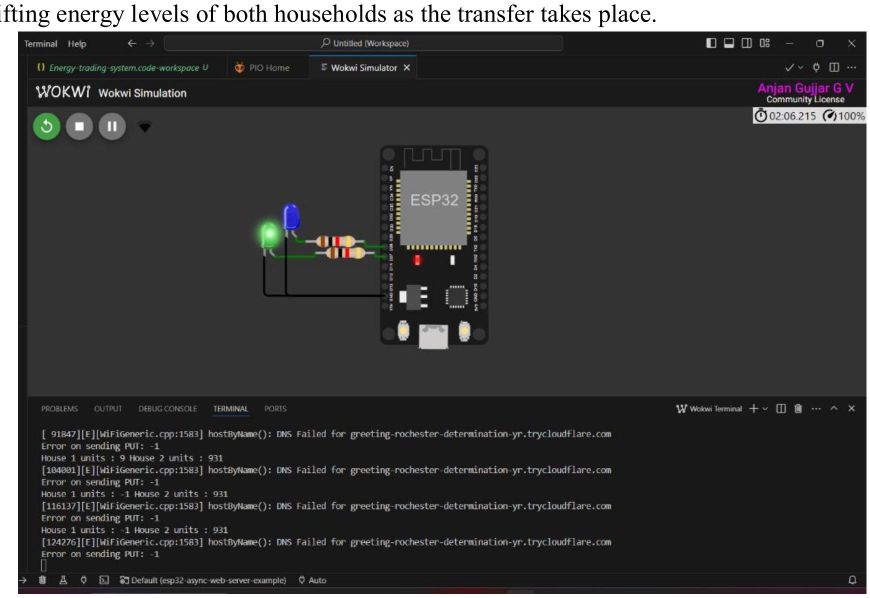

Fig. 2. Example of an unacceptable low-resolution image

The green light in House 2 dims as its energy level drops, and the blue light in House 1 brightens as its energy level rises. Users can more easily comprehend the transer procedure thanks to this visual portrayal. To make sure the terminal correctly depicts the energy transfer, data is gathered during the execution by noting the initial and final energy levels. The functionality of the ESP32 is put through a thorough testing process to ensure that it updates the terminal readings and regulates energy transfer accurately. We make observations to verify that the energy levels shown in the terminal correspond with the visual feedback coming from the bulbs. Security measures are put in place to guarantee data integrity and safe communication. These procedures also ensure that the data displayed is ac-curate and that unauthorised access is prevented. The system's effectiveness is demonstrated by the successful transfer of 69 units of energy, which is validated by terminal measurements and bulb status. This methodology not only demonstrates the possibility of real-time energy trading in a peer-to-peer (P2P) system, but it also offers a strong foundation for additional research and development aimed at improving comprehension of the dynamics involved in energy transfer between engaged parties.

VI. RESULTS AND DISCUSSION

The P2P energy trading system's implementation of single cycle energy trans-fer via an ESP32 microcontroller produced encouraging results, proving the viability and efficiency of real-time energy exchange between involved parties. The energy transfer process was effectively communicated to users through visual aids including terminal displays and coloured lamps, which improved comprehension and engagement. Based on terminal readings and visual input from the lights, the system effectively transferred 69 units of energy from House 2 to House 1 in a single cycle. This demonstrates that the system can enable accurate and timely energy transfers in a peer-to-peer energy trading setting. Additionally, the energy transfer process' precision and dependability were guaranteed by the testing and validation processes. The transfer was successfully completed, as evidenced by data gathered from the beginning and final energy levels, and thorough testing of the ESP32's capabilities verified that it could effectively manage the transfer process and update terminal readings. The implementation of security measures aimed at protecting data integrity and communication integrity served as additional confirmation of the system's resilience and appropriateness for practical use.

The findings of this study add to the expanding corpus of knowledge on peer-to-peer (P2P) energy trading systems by shedding light on the viability from a technical and practical implementation standpoint of real-time energy exchange. This technique establishes the foundation for further research and development aimed at optimising energy distribution and utilisation in sustainable energy sys-tems by showcasing the efficacy of the ESP32-based energy transfer system. P2P energy trading systems have the potential to completely transform the energy market and enable people and communities to have an active role in the shift to a more sustainable future through further development and scalability.

VI. CONCLUSION

This study presents an approach that uses an ESP32 microcontroller in a peer-to-peer (P2P) energy trading system to successfully implement a single cycle energy transfer between two residences. The energy transfer process was successfully communicated through visual aids like terminal displays and colored lighting, giving users immediate feedback. The system demonstrated its ability to enable prompt and precise energy transactions by executing the transfer of 69 energy units from House 2 to House 1 in a single cycle. The system's resilience and functionality were validated by the testing and validation methods, which also established the energy transfer process' precision and dependability. In addition, security protocols were put in place to protect communication and data integrity, guaranteeing the system's applicability for practical uses.

Overall, by shedding light on the viability from a technical and practical implementation standpoint of real-time energy exchange, this work advances peer-to-peer energy trading systems. P2P energy trading systems have the potential to completely change the energy landscape and hasten the shift to a more sustainable future by enabling individuals and communities to actively participate in the distribution and use of energy. To improve energy trading mechanisms and en-courage the broad use of P2P energy trading systems, further study and develop-ment in this field are necessary.

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