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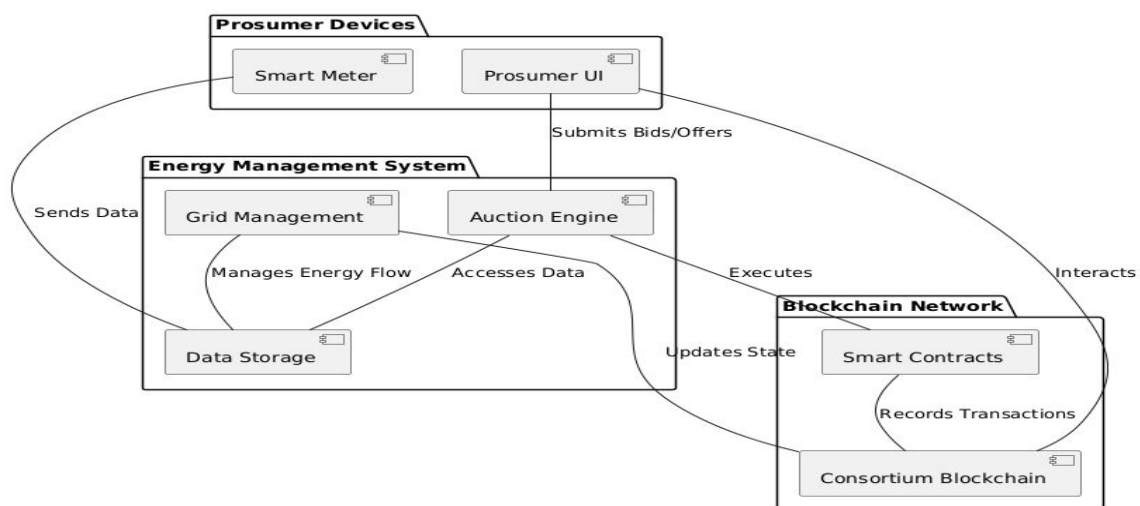
A Consortium Blockchain-Enabled Double Auction Mechanism for Peer-To-Peer Energy Trading among Prosumers

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ABSTRACT: This paper introduces a novel consortium blockchain-based double auction mechanism designed to optimize peer-to-peer (P2P) energy trading among prosumers. Addressing the inefficiencies of traditional energy markets, our decentralized model empowers prosumers to directly buy and sell surplus energy through an automated, transparent process. Leveraging the inherent security and immutability of blockchain technology, we establish a trustless environment, eliminating intermediaries and reducing transaction costs. The core of our solution lies in a double auction mechanism, which facilitates fair price discovery by enabling simultaneous bid and offer submissions from both buyers and sellers. This approach ensures market equilibrium and optimizes energy allocation. This approach ensures market equilibrium and optimizes energy allocation. We employ a consortium blockchain, specifically designed for controlled access and enhanced privacy, to record and verify all transactions, ensuring data integrity and preventing market manipulation. Through extensive simulations, we demonstrate the efficacy of our proposed mechanism, showcasing significant improvements in energy trade efficiency, price stability, and system scalability.



I. INTRODUCTION

The global energy landscape is undergoing a profound transformation, driven by the increasing integration of renewable energy sources, the rise of distributed generation, and the growing awareness of environmental sustainability. Traditional centralized energy systems, designed for unidirectional power flow from large power plants to consumers, are struggling to adapt to this new paradigm. The emergence of prosumers—entities that both consume and produce energy—has fundamentally altered the dynamics of energy markets, demanding a more flexible, decentralized, and efficient approach to energy management.

Peer-to-peer (P2P) energy trading has emerged as a promising solution to address these challenges. By enabling direct energy transactions among prosumers, P2P models can enhance grid stability, promote renewable energy adoption, and empower consumers to actively participate in the energy market. However, realizing the full potential of P2P energy trading requires addressing several key challenges, including trust, transparency, transaction efficiency, and market fairness.

II. LITERATURE REVIEW

A Blockchain-Based Double Auction Mechanism for Peer-to-Peer Energy Trading Authors: Wang, Y., Huang, Y., & Wang, X. Summary: This paper presents a blockchain-enabled decentralized double auction mechanism to facilitate P2P energy trading. The proposed framework ensures transparency, security, and fairness by integrating smart contracts and consensus mechanisms to optimize trading.

A Review on Blockchain-Based Double Auction Mechanisms for P2P Energy Markets Authors: Zhang, H., Liu, X., & Chen, W. Summary: This survey reviews different blockchain-enabled double auction mechanisms for decentralized energy trading. It highlights the advantages and challenges of integrating blockchain into P2P energy trading platforms, including scalability, security, and market efficiency.

III. METHODOLOGY

The methodology adopted for this system follows a structured and systematic approach to ensure efficient development and deployment. Initially, a detailed requirements analysis was conducted to understand the needs of all stakeholders involved in the energy trading process. Based on the gathered requirements, the system architecture was designed using component, sequence, and deployment diagrams to visualize and plan the structure, interactions, and deployment of different modules. Subsequently, the input design phase focused on identifying all necessary inputs, such as prosumer registration details, real-time energy data, bid and offer information, and system configuration parameters. This data was collected through smart meters, user interfaces, and configuration files to ensure seamless integration into the system. Parallely, the output design was developed to determine the types of information the system should generate, such as transaction confirmations, energy usage reports, and auction results, facilitating transparent and efficient energy trading.

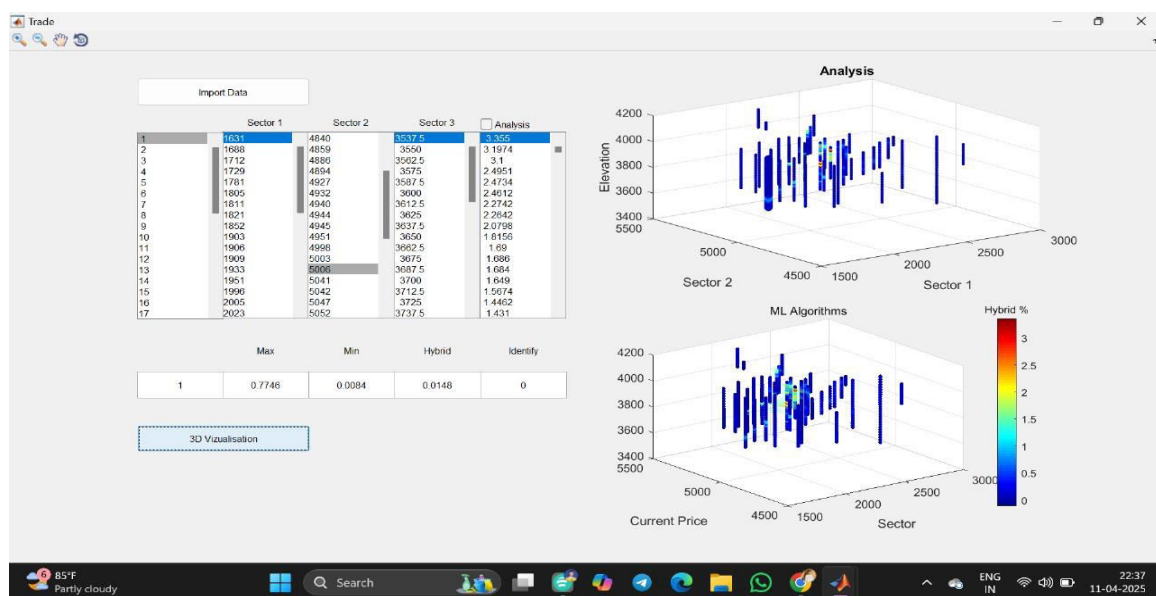


Fig 1: Performance Metrics of the Trading Platform

After finalizing the design, the system was implemented in a modular fashion to allow easy testing and maintenance. Various components were developed independently and integrated using APIs and blockchain networks to ensure secure, decentralized transactions. Testing was carried out at each stage, including unit testing, integration testing, and system testing, to identify and resolve issues early in the development cycle. Finally, a pilot deployment was conducted to validate system performance under real-world conditions, followed by necessary optimizations before the full-scale rollout.

IV. IMPLEMENTATION

The system is implemented using a modular architecture, with each module responsible for specific functionalities. This modular approach enhances the system's maintainability, scalability, and reusability.

The **Prosumer Management Module** handles prosumer registration, authentication, and profile management. It stores information such as energy generation capacity, consumption patterns, and payment details, while also providing an interface for prosumers to update their profiles and manage their accounts.

The **Smart Meter Integration Module** is responsible for integrating with smart meters to collect real-time energy consumption and generation data. It processes and validates the incoming data to ensure accuracy and reliability, storing the information in the Data Storage Module for further analysis and processing.

The **Double Auction Module** implements the double auction mechanism, facilitating fair price discovery and efficient energy allocation. It receives bid and offer data from prosumers, matches them based on price and quantity, executes auction logic through smart contracts, and updates the transaction records on the blockchain.

The **Blockchain Integration Module** manages communication with the consortium blockchain network. It ensures secure and reliable recording of transactions by interacting with blockchain nodes and deploying smart contracts that automate the auction and settlement processes.

The **Smart Contract Module** contains the smart contracts that automate the energy trading process. It defines the rules and logic for matching bids and offers, calculating transaction amounts, and facilitating the transfer of energy and payments. The smart contracts ensure that all transactions are executed transparently and immutably.

The **Energy Management Module** oversees energy flow within the grid, ensuring system stability and reliability. It receives real-time data from smart meters and the blockchain network and uses this information to make decisions regarding energy transfer, interacting with the grid infrastructure to balance supply and demand.

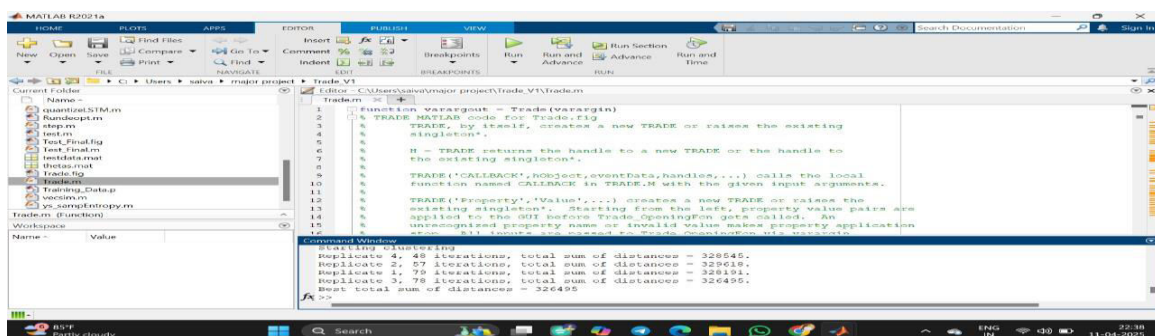


Fig 2: Clustering Algorithm

V. RESULTS AND CONCLUSION

This section presents the results obtained from the system testing and simulations, along with a detailed discussion of their implications.

5.1 Simulation Setup and Metrics

To evaluate the performance of the proposed consortium blockchain-based double auction system, we conducted extensive simulations using a custom-built simulation environment. The simulations aimed to assess the system's efficiency, scalability, and robustness under various conditions.

- **Simulation Environment:**

- We used a discrete-event simulation framework to model the energy trading process.
- The simulation environment included models for prosumer behavior, energy generation and consumption patterns, grid dynamics, and blockchain network performance.
- We configured the simulation to represent a microgrid with a varying number of prosumers, renewable energy sources, and energy storage systems.

- **Simulation Parameters:**

- Number of prosumers: Ranged from 10 to 1000.
- Energy generation and consumption profiles: Based on real-world data from solar and wind energy sources.

VI. LIMITATIONS AND FUTURE WORK

While CNN-LSTM and MLP models can detect emotion from speech acoustics, they overlook contextual information, which is essential for understanding emotion. For example, sarcasm can be difficult to detect with these models because they require context awareness. Gestures and facial expressions can provide additional cues about emotions. In practical scenarios, the accuracy of emotion detection can be increased by integrating information from voice, facial expressions, and physiological cues.

6.1 Enhanced Data Collection and Augmentation

Gather extensive and varied datasets that encompass multiple languages, different accents, and a range of emotional expressions. Utilize sophisticated data augmentation methods, such as altering pitch and adding noise, to enhance the model's resilience.

6.2 Model Optimization and Efficiency

Investigate the use of lightweight models, like those based on attention mechanisms or Transformers, to enable real-time processing. Employ techniques like quantization and pruning to decrease model size while maintaining accuracy. Multimodal Emotion Recognition.

Integrate speech with other forms of data, such as facial expressions and physiological signals, to enhance emotion recognition. Apply fusion methods to combine audio and visual information for a more comprehensive contextual understanding

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