A Decentralized Peer-to-Peer Energy Trading Platform using Hyperledger Composer

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ABSTRACT

Our project constructs a decentralized energy grid with blockchain (Hyperledger Composer) to facilitate peer-to-peer energy exchange. Homeowners with excess renewable energy, like solar energy, can sell excess energy directly to others via secure smart contracts and a token system. Transactions are stored immutably on the blockchain, providing transparency and trust. A prepaid mechanism facilitates users to pre-buy tokens so that they could be used in payment for energy, and for converting tokens back into fiat forms such as USD. The utility companies are integrated into the system as well to make energy exchange smooth and free-flowing between local communities.

Keyword: - *Blockchain Technology, Peer-to-Peer Energy Trading, Smart Contracts, Token-Based System*

1. INTRODUCTION

The incorporation of Hyperledger Composer within a decentralized power network increases the level of security, transparency, and efficiency among peer-to-peer power trading. By utilizing blockchain technology, energy exchange between residents is efficiently recorded within an immutable record book, where the level of trust is provided while intermediaries become unnecessary. People who have excess renewable energy, for example, from solar panels, can easily sell their excess to others who need it using smart contracts, which execute transactions according to agreed-on pricing terms.

A token-based system simplifies payment, which allows residents to buy energy with prepaid tokens that can be exchanged for fiat currency. In addition, Hyperledger Composer's modular design allows for integration with current utility providers, facilitating buying and selling of energy in one platform. This deployment not only enhances security and transparency but also maximizes energy distribution, making decentralized energy trading more efficient and sustainable.

2. EXISTING ENERGY TRADING SYSTEMS

Current energy trading systems are based mainly on centralized utility companies that control energy distribution, pricing, and billing. Conventional energy grids function in a top-down model, where electricity is produced at large power plants and sold to consumers via intermediaries. Consumers in most instances have little control over energy prices and supply since utility companies control the market. Renewable energy sources like solar panels on individual homes tend to struggle with grid integration, needing complicated deals with utilities to sell back excess energy. Although some net metering systems permit consumers to earn credits for excess energy, the process tends to be slow, inflexible, and centrally controlled.

DISADVANTAGES IN THE EXISTING SYSTEM

Although energy management has improved, centralized trading systems of energy have a number of disadvantages. One of them is lack of transparency as utility companies exercise control over price, bill, and transaction, resulting in consumers having minimal access to information or control. High administrative and operational costs of centralized intermediaries add to inefficiencies, further pushing up the cost of electricity for final consumers. Further, settlement delays and energy trading slow down real-time transactions, making efficient distribution of excess energy impossible. Poor accessibility for small-scale renewable generators denies homes

with solar panels the ability to sell excess energy. Further, security threats, data loss, and distrust of centralized control lower confidence in the system. In total, these inefficiencies are obstacles to a seamless, low-cost, and transparent peer-to-peer energy trading system.

3. PROPOSED SYSTEM

Our Peer to Peer distributed energy trading platform depends on Hyperledger Fabric to establish an open, secure, and efficient P2P energy market. Utilizing blockchain, the platform offers a mechanism through which homes with excess renewable energy (such as solar) can trade directly with consumers without the involvement of centralized utility companies. Hyperledger Fabric offers a permissioned blockchain architecture, where all transactions are tamper-proof, auditable, and securely stored on an irreversible ledger. Energy transactions are regulated by smart contracts, which offer real-time pricing, billing, and settlement. It removes delays, removes middlemen, and increases trust among participants. To ensure efficient energy payments, the system includes a prepaid token-based system, under which the users buy energy tokens in advance that allow seamless transactions. In addition, a fiat conversion feature facilitates convenient token-to-standard currency conversion, linking the decentralized network to the conventional financial networks. Through the consolidation of utility companies, the system provides interoperability with the existing grid, hence enabling smooth transactions for customers to buy or sell energy. The blockchain-based system not only improves efficiency and cost-effectiveness but also gives consumers greater control over their energy consumption and financial transactions, hence a sustainable and decentralized energy system.

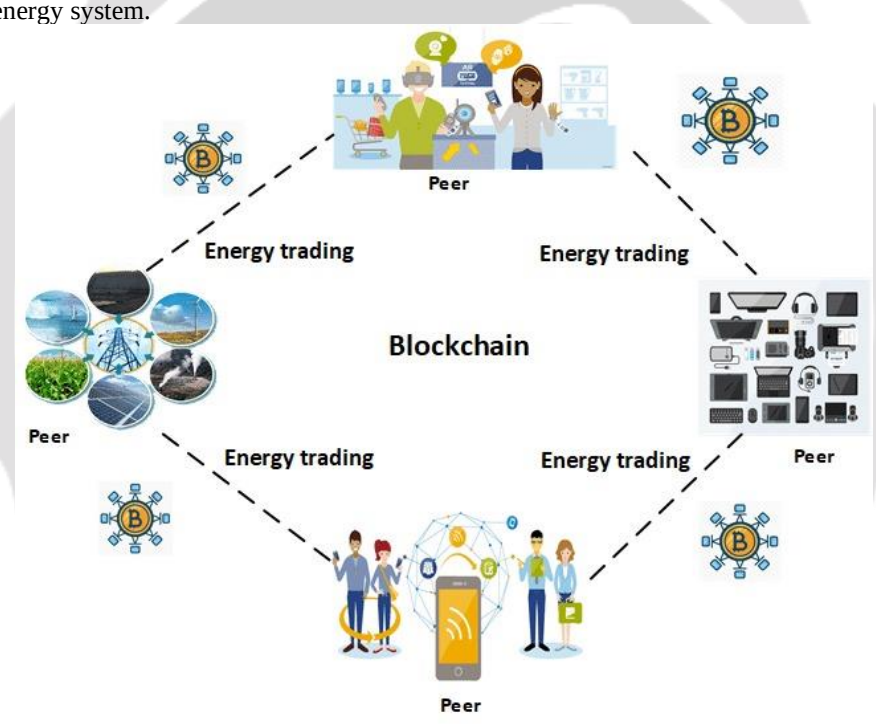

Fig-1: Block Diagram representing the network

3.1 Prerequisites & Environment

- **Docker:** It is a platform that allows developers to package, distribute, and run applications within isolated environments called containers. In the context of building a network using Hyperledger Fabric, Docker is essential because it enables the easy deployment and management of Fabric components such as peers, orders, and other network entities in separate containers.

- **Node.js:** Node.js is a runtime environment that allows developers to run JavaScript code outside of a web browser, making it particularly suitable for server-side applications. In the context of building a network using Hyperledger Fabric, Node.js is essential for developing smart contracts and building client applications to interact with the Fabric network.

- **CLI:** Composer-CLI is a command-line tool provided by Hyperledger Composer, a framework for rapidly building blockchain applications on top of Hyperledger Fabric. Composer-CLI is essential for

building a network using Hyperledger Fabric as it offers commands for creating, deploying, and managing business networks defined using Composer modeling language.

- **Rest Server:** Composer-REST-Server is a tool provided by Hyperledger Composer that automatically generates a RESTful API for a business network deployed on Hyperledger Fabric. Its necessity in building a network using Hyperledger Fabric lies in its ability to simplify and accelerate the development of client applications that need to interact with the blockchain network.

- **Yeoman:** Yo, short for Yeoman, is a robust scaffolding tool that aids developers in generating project structures and automating repetitive tasks. In the context of building a network using Hyperledger Fabric, Yo is necessary because it serves as the foundation for tools like Generator-Hyperledger-Composer.

- **Generator Hyperledger Composer:** Generator-Hyperledger-Composer is a Yeoman generator that helps developers' scaffold Hyperledger Composer project structures, including business networks, participants, assets, transactions, and events. Its necessity in building a network using Hyperledger Fabric stems from its ability to streamline and standardize the initial setup and configuration process.

3.2 Methodology

In the network, we find two most important assets: "energy transaction" and "energy unit." The assets carry important information regarding energy trading, including ownership information, transaction history, and energy allocation. There are two most important players too: the "energy producer" and the "energy consumer." The energy producer is the one that produces and supplies energy to the network, and the energy consumer participates in energy trading by purchasing energy units.

Exchanges in the network allow interaction, for instance:

Energy producers initiate exchanges by adding units of energy into the blockchain platform.

Customers buy energy from providers, and the exchange is recorded on the blockchain ledger.

A smart contract automatically checks transactions, hence ensuring safe and open trading procedures.

This peer-to-peer energy trading system based on blockchain ensures efficient energy distribution, eliminates middlemen, and facilitates transparency and security for peer-to-peer energy trading.
Steps to implement are as follows:

- Install prerequisites for Hyperledger Composer.
- Install environment for the development of the project.
- Download and configure Hyperledger Fabric on the system.
- Create a business network and define the assets (land record, land parcel), participants (land registry, government agency), and transactions (create, update land record).
- Implement access control to restrict modifications to the network to the land registry.
- Start the Hyperledger Fabric Business network.
- Finally, interact with the network using a Angular Web Application.

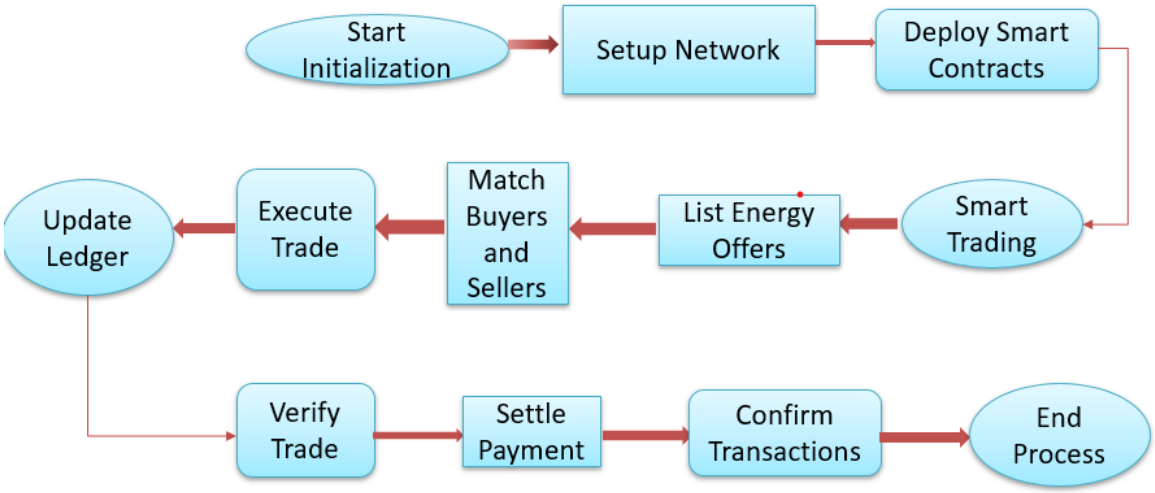

FIG-2 Design Methodology

4. RESULT

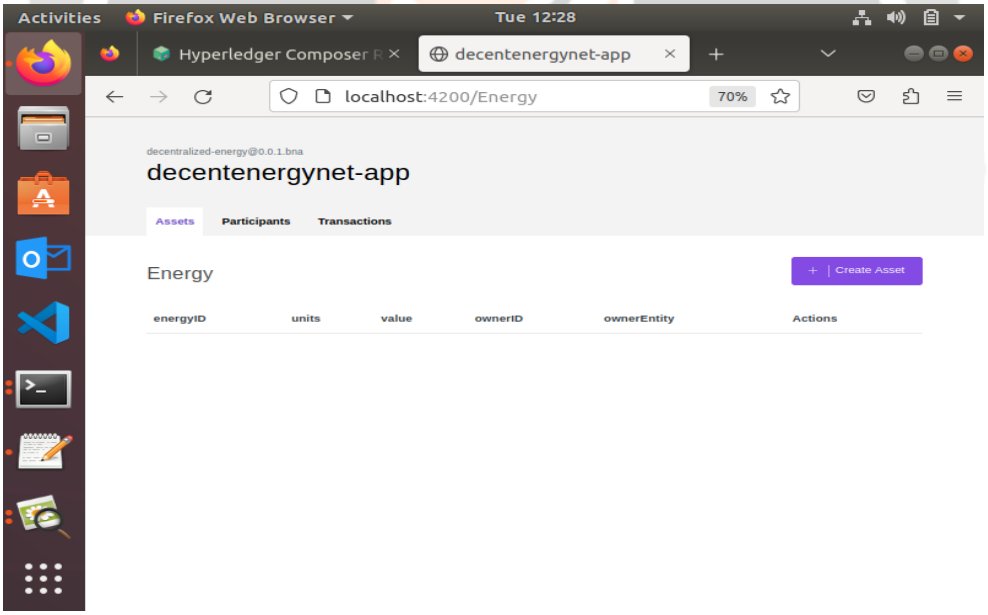

FIG-3-: Angular Web Application

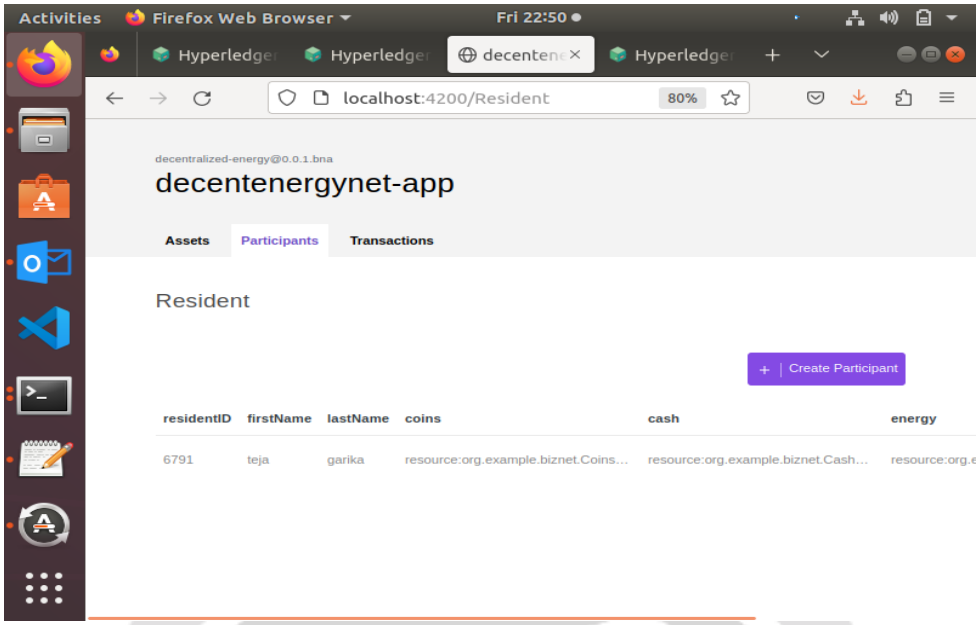

FIG-4-: Participants

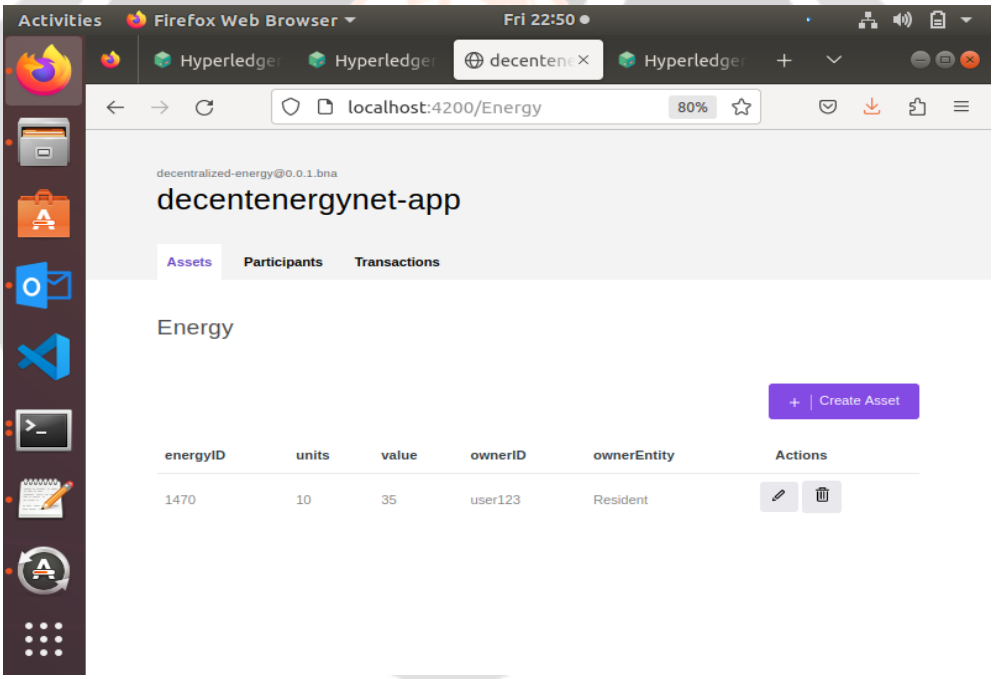

FIG-5: Assets

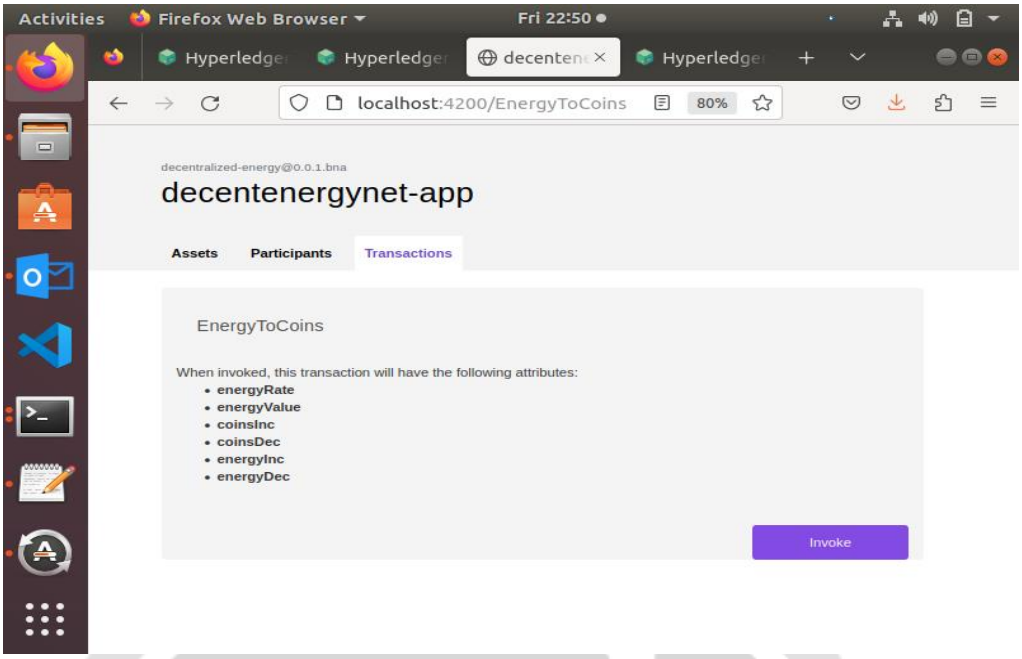

FIG-6: Transactions

5. CONCLUSIONS

The establishment of a decentralized energy trading system through the employment of blockchain technology, here using Hyperledger Fabric, is a highly valuable and innovative method. Blockchain employment enables a pivotal shift in energy trading through guaranteeing transparency, security, and efficiency in peer-to-peer energy trading. Through the permanent storage of energy production, consumption, and transactions in a decentralized ledger, blockchain greatly minimizes fraud, unauthorized access, and inefficiencies in conventional energy distribution systems. The adoption of Hyperledger Fabric also adds further customization and scalability, enabling energy producers and consumers to participate in secure and reliable energy trading.

The adoption of blockchain technology and Hyperledger Fabric dramatically enhances the trust value of energy transactions, minimizes the utilization of middlemen, and ensures real-time, tamper-proof record keeping. In addition, smart contracts ease transaction operations, ensuring secure financial exchanges and energy delivery based on agreed-upon stipulations. The decentralized environment of blockchain ensures effective data sharing and interoperability among energy producers, consumers, and authorities, thus establishing an efficient and sustainable energy system.

To further develop the project, it is critical that continuous research and development efforts aim at improving scalability, performance, and user experience. Research work on advanced analytics for real-time energy consumption analysis and implementation of AI-based demand forecasting would greatly enhance the efficiency of the system. Additionally, collaborations with government agencies, energy experts, and technology entrepreneurs to address regulatory compliance and governance matters would guarantee long-term success and adoption of blockchain-based energy trading systems. In conclusion, the adoption of Hyperledger Fabric for energy management can revolutionize decentralized energy trading, making the energy market secure, transparent, and efficient for the future.

6. REFERENCES

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