Journal of Information Systems Engineering and Management
2025, 10(10s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

Decentralized Energy Trading Framework With Active Pricing Via Blockchain Smart Contracts

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ARTICLE INFO

Received: 02 Nov 2024

Revised: 26 Dec 2024

Accepted: 04 Jan 2025

ABSTRACT

With the use of IoT devices and blockchain technologies, consumers can purchase and sell energy straight from the grid instead of going via retailers. Here, existing research proposed a various model but it has several limitations such as scalability, less optimal, and efficiency. Therefore, this research proposed a novel Decentralized Energy Trading Framework via Block-chain Smart Contracts. Initially, we obtain a dataset, which consists of total incoming energy (from producers), total outgoing energy (to consumers), price for incoming energy, and price for outgoing energy. Then, this research proposed a Concatenate Hash approach, to generate private and public keys to enhance security and efficiency. Following that, this research proposed a Weighted Scoring Technique for energy trading here Deputized Proof of Stake (DPOS) is used to verify the integrity of blocks which increases scalability and efficiency by reducing the number of participants in the consensus process. Then, for energy trading the consumer could calculate a score for each prosumer using a weighted average considering both energy availability and price. Moreover, Profit generating is the primary factor used to encourage customers and buyers to take part in suggested P2P energy trading. Consequently, Income Generation based on an active pricing strategy was proposed by this research. As a result, our proposed approach has less latency, higher throughput, and security.

Keywords: Blockchain, Peer-to-peer energy trading, Security, Smart contract, hashing approach

1. Introduction

Technological advancements such as rooftop solar photovoltaic [1] and distributed energy resources like EV and BESS [2–5] have improved customer involvement in energy generation and management within the SG system. Since it reduces the burden on electric utility companies, P2P Transactive energy trading is one of the most significant techniques in Singapore. P2P increases demand-response equilibrium, increases the usage of renewable energy, and increases system flexibility.

In a traditional energy supply, customers pay time-of-use or fixed tariffs to merchants or utilities for energy. Accordingly, prosumers [6] who generate in addition to consuming, or self-consumers can use the buy-back rate to return extra energy to the SG for sale. However, prices for consumers' energy supply are more expensive than the prosumers' buy-back rates. Energy trading in this case requires the participation of retailers and utility corporations. Moreover, by producing energy from renewable energy sources like windmills and SPV, P2P creates decentralized energy market models [7]. P2P energy trading occurs when two or more prosumers and consumers with SG connections are utility providers [8]. In this regard, a great deal of study has previously been done [9–13]. A P2P trading framework was presented by Javadi et al. [9] after they examined completely decentralized energy trading model within a TEM system. In a decentralized system, consumers obtain a good offer at a fair price from prosumers. P2P hence requires openness when interacting with customers in a decentralized environment [14]. The literature on peer-to-peer energy trading suggests that energy marketplaces fall into four groups: (i) Complete P2P market: In this scenario, prosumers and consumers engage in direct energy trading. It has scaling problems with P2P negotiation procedure and the regional energy equilibrium that SG managers oversee (i.e., setting a target price) [15]. (ii) Community-based markets: In these situations, pricing negotiations between prosumers and consumers are handled by the SG community coordinator to reach an equilibrium price [16]. (iii) Mixed peer-to-energy market: consumers and users are involved in this trade of energy directly with the grid as well as with each other, eliminating the need for a middleman. The P2P mechanism can be used to construct this local energy market [17]. (iv)Localised P2P market: It doesn't rely on a reliable third party and is intended for PHEV [18]. Then there is the micro-market, which guarantees network constraints and preserves competition among utility providers for societal benefit. The current infrastructure reduces duplication and maximizes cost-effectiveness by offering a centralized peer-to-peer exchange platform [19, 20]. But as trade requests and consumer energy demands rise, its dependability, performance, latency, and network bandwidth deteriorate. Single-point-of-failure, privacy, trust, and security vulnerabilities are other issues.

Blockchain is a digital ledger technology that has shown promise in several industries, including cryptocurrencies and healthcare. Because keeping data on a blockchain is expensive, the current energy trading system that relies on it for transactions inefficiently records energy transactions. This study used blockchain smart contracts to develop a unique "Decentralised Energy Trading Framework," which was inspired by the aforementioned gap.

- The first step is the concatenate hash approach which generates private and public keys after the request for P2P trade is accepted these facilitate secure transactions. Here, SHA-256 with salting hash is used to generate the private key and the public key. Hence, salting with hashing contributes to preserving the integrity of data stored in blocks.

- Then, this research proposed a Weighted Scoring Technique for energy trading, here, the prosumer uses the smart contract to start a trade request on a decentralized blockchain platform to trade excess energy and the marketplace for Transactive power.

- In addition, the proposal suggests generating profit through an active pricing structure that benefits both prosumers and consumers. It uses a dynamic pricing structure to increase the profit margin for prosumers as well as consumers.

This research paper has the following format: In Section 2 of the study, a peer-to-peer clever contract-based energy trading network is explored, and in Section 3, the recommended approach is detailed. Subsequently, the implementation outcomes are shown in Section 4, and the decision is presented in Section 5.

2. Literature Survey

At the micro-grid level, distributed P2P energy trading has recently been studied. A P2P paradigm was put up by Liu et al. [24] for nearby microgrids to reduce energy costs and increase DER utilization. Next, a P2P trading system was suggested by Long et al. [11], who employed a game-theoretic method for decision-making. The method achieves P2P energy trading's optimality and fairness, but it requires batteries.

Using blockchain, Dorri et al. [12] presented the SPB platform as a POC. SPB reduces processing time and costs for energy trading. But utilizing a larger test where different energy providers and consumers bargain and trade energy, isn't scalable.

A public Ethereum network with SC support was unveiled by Seven et al. [13] for peer-to-peer trade. The writers suggested a platform for bidding through auctions that links several technologies, including the remix, Infuro.io, Metamask, which solidity, and Ropsten, to facilitate blockchain-based energy trade. Next, a unique blockchain platform framework was presented by Han et al. [25] to link the requirements of consumers and the resources of producers. Here, the SC can be used to trade energy with more than 25 people at once. It does not, however, take into account increasing the platform's capabilities, which causes scaling problems. Wongthongtham et al. [26] looked at the best way to use blockchain for peer-to-peer energy trading. The outcome demonstrates how economical the strategy is. In addition, Li He et al. [27] suggested an energy-sharing system based on energy pawns (EP). It raises the money that the EP makes. Forecasting-based energy capacity scheduling algorithms and customized dynamic pricing are described here. It does not, however, have the technology for more precise energy forecasting, which would further increase market efficiency. A P2P power token interchange method founded on blockchain technology has been future by Mehdinejad et al. [28]. The suggested strategy guarantees a practical and global solution without requesting any personal data from prosumers and customers. It isn't used in practical applications, though. P2P energy trading has been the subject of several works, although it has not yet received enough attention.

3. Decentralized Energy Trading Framework Via Block-Chain Smart Contracts

Prosumers and consumers in a microgrid can exchange tiny amounts of energy throughout brief trading intervals thanks to the traditional energy trading system. An approach to energy trading as well as using game theory to guide decisions, an architecture for energy trade based on Secure Private Blockchain, an auction-based bidding platform that is open to the public and SC-enabled, a new blockchain technology for, and a leverage blockchain platform for token interchange are some examples of the limitations of current research. Furthermore, IPFS is used for data storage in present research, albeit it has latency and bandwidth constraints. A unique structure is suggested to get beyond these restrictions, as seen in Figure 1.

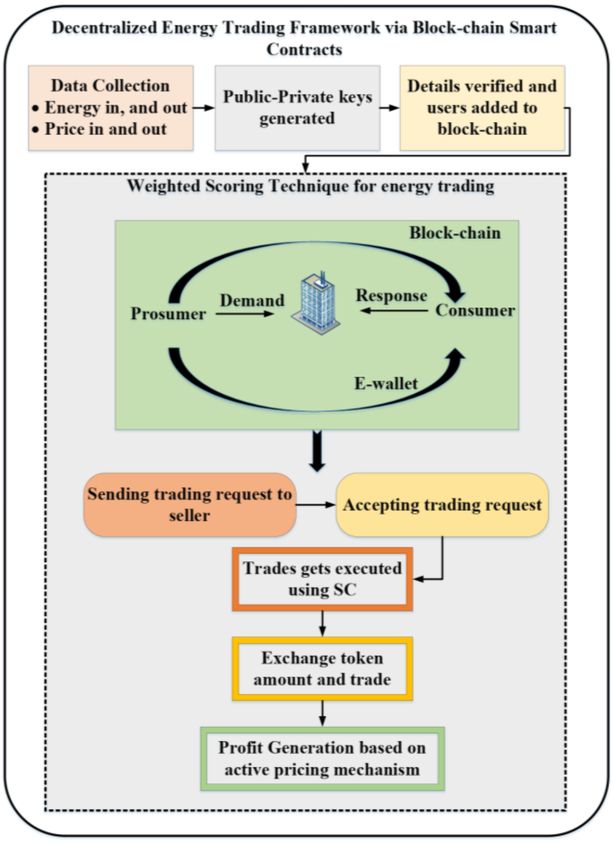

Fig. 1. Architecture of the proposed approach

3.1 Block-chain with smart contracts

Initially, we obtain a dataset, which consists of total incoming energy (from producers), total outgoing energy (to consumers), price for incoming energy, and price for outgoing energy. Here, blockchain with smart contracts represents a symbiotic integration of decentralized ledger technology and self-executing digital contracts. Blockchain, functioning as a distributed and immutable ledger across a network of computers, ensures transparency and security by cryptographically linking blocks of transactions. Moreover, smart contracts operate as automated, predefined agreement protocols that trigger actions when specified conditions are met. These contracts eliminate the need for intermediaries by enforcing agreements without centralized oversight, enabling trustless and transparent interactions. Despite offering transparency and automation, challenges such as security vulnerabilities in smart contract code, scalability limitations, and evolving regulatory frameworks persist, requiring ongoing development and innovation for broader adoption and scalability.

Therefore, this research proposed a concatenate hash approach, to generate private and public keys once the P2P trading request is approved these facilitate secure transactions. Here, SHA-256 with salting hash is employed to produce the public key and the private key. Hence, salting with hashing contributes to preserving the integrity of data stored in blocks by making the hash values less predictable and more resistant to tampering attempts. Hence, it enhances the security and efficiency of this framework. To enable users to search for files using the keys, this research generates keys for the uploaded energy data files. Figure 3 displays the hybridized data security model's conceptual diagram.

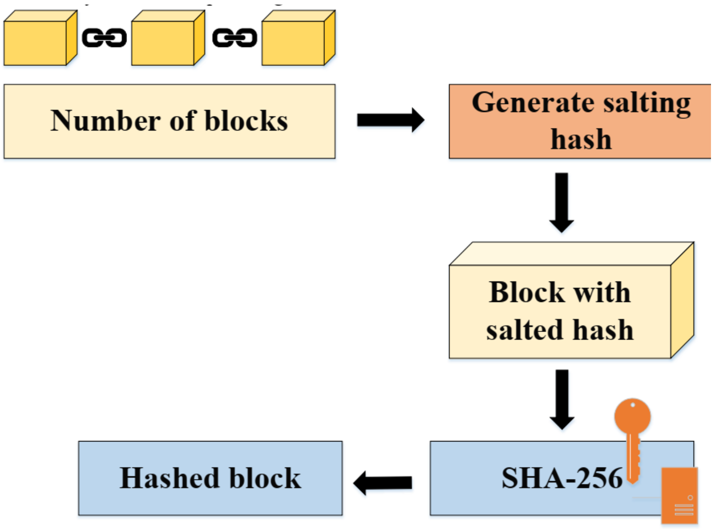

Fig. 2. Conceptual diagram of the hybridized data security model

A salt, which is a randomly generated string of characters, is added to the initial block before hashing. The purpose of salting is to add uniqueness and complexity to each block's hash, making it more resistant to attacks. Salted block hashing adds more unpredictability to the hashing process, which can be utilized to increase block security. With the addition of salt, an attacker finds it more It is difficult to deduce the original plaintext of a block that has been hashed with a cryptographically secure random string if one does not have access to both sources. As an extra layer of encryption, salted hashing necessitates the use of a distinct and arbitrary "salt." This implies that to carry out the password hashing procedure, every known salt (or collection) is needed.

Next, SHA-256, regarded as the SHA-2 family's representative, is used to protect data on decentralized blockchains at the moment.

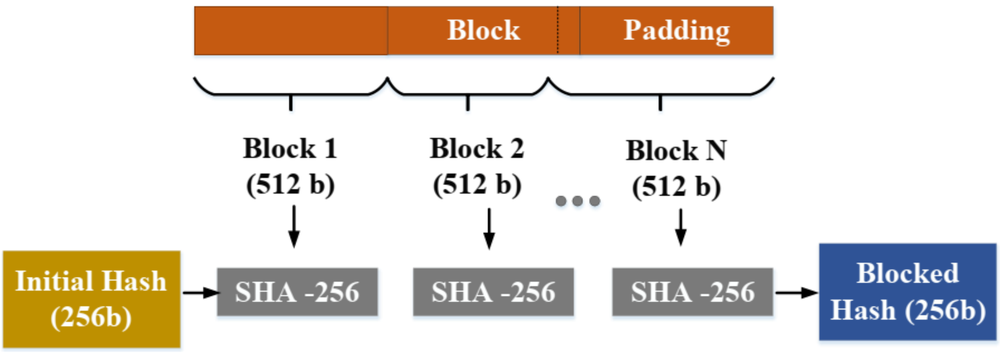

Fig. 3. The generation of a SHA-256 hash value for a long message

With 512 bits of input data, SHA-256 generates a 256-bit hash value. Several 512-bit data blocks make up the block. Padding is added in the final block if its bit count is less than 512. Figure 3 illustrates the hash calculation for a large block. By analyzing each data block separately, the SHA-256 algorithm calculates intermediate hash values. This preceding block's hash value serves as the initial hash value for the hash computation of the subsequent block. The final data block result is what is regarded as the hash value of the message.

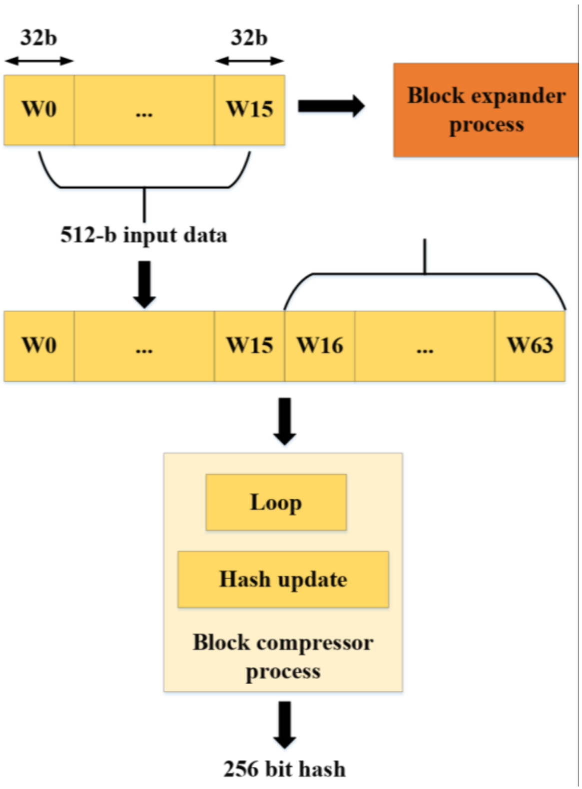

Fig. 4. The overview operation of the SHA-256 algorithm.

Figure 4 demonstrates how the SHA-256 algorithm works in general. The block compressor and block expander are two of its processes. The input of the 512-bit block is expanded into 64 32-bit data segments Wj (0≤j≤63) via block expander method. The 512-bit block is parsed by sixteen 32-bit information segments (denoted as Wjj = 0 to 15, where j is the round index) by the block expander in the first 16 rounds. The block expander uses equation 1 to determine 48 pieces of 32-bit data Wj (16≤j≤63) in the last 48 cycles. To compute Wj (16≤j≤63), two reasons, σ0 (x) and σ_1 (x), and three 32-bit adders are required. Equations (2) and (3) are used to calculate σ0 (x) and σ_1 (x).

$$W_j = \sigma_1(W_{j-2}) + W_{j-7} + \sigma_0(W_{j-15}) + W_{j-16} \quad (1)$$

$$\sigma_0(x) = S^7(\mathrm{x}) \oplus S^{18}(x) \oplus R^3(\mathrm{x}) \quad (2)$$

$$\sigma_1(x) = S^{17}(\mathrm{x}) \oplus S^{19}(x) \oplus R^{10}(\mathrm{x}) \quad (3)$$

The block compressor process uses the 64 pieces of Wj (0≤j≤63) that are output from the block expander process to calculate the 256-bit hash value. Hash updates and loops are the two primary steps in the process. The starting hash values H0, H1, and H7. are used to initialize eight-ring hash standards (denoted a, b, c, d, e, f, g, and h) in the loop step. 64 loops are then used to calculate and update the ring hash ethics, which are a, b, c, d, e, f, g, and h. Equations (4) through (8) are used in every loop (loop j, 0 ≤ j ≤ 63).

$$T_1 = h + \sum_1(e) + Ch(e,f,g) + K_j + W_j \quad (4)$$

$$T_2 = \sum_0(a) + Maj(a,b,c) \quad (5)$$

$$a = T_1 + T_2 \quad (6)$$

$$e = d + T_1 \quad (7)$$

$$b = a; c = b; d = c; f = e; g = f; h = g \quad (8)$$

When rational operations like, $Ch(x,y,z,)$ and $Maj(x,y,z)$ are calculated using the subsequent formulas.

$$\sum_0(x) = S^2(\mathrm{x}) \oplus S^{13}(x) \oplus R^{22}(\mathrm{x}) \quad (9)$$

$$\sum_1(x) = S^6(\mathrm{x}) \oplus S^{11}(x) \oplus R^{25}(\mathrm{x}) \quad (10)$$

$$Ch(x,y,z) = (x \wedge y) \oplus (\neg x \wedge z) \quad (11)$$

$$Maj(x,y,z) = (x \wedge y) \oplus (x \wedge z) \oplus (y \wedge z) \quad (12)$$

During the hash update stage, the loop hashes a, b, c, d, e, f, g, and h are added to the starting hashes H_0, H_1,..., H_7 to obtain The last hash value is (256 bits), which is separated into 8 pieces of 32-bit data [HO]_0,[HO]1,...,[HO]_7. This process demonstrated in eq. (13).

$$HO_0 = H_0 + a; \ldots; HO_7 = H_7 + h \qquad (13)$$

Hence, this research generates the keys for the blocks. Following that, a decentralized blockchain platform using smart contracts is used to develop for energy trading.

3.3 Weighted Scoring Technique for Energy Trading

Next, utilizing a decentralized blockchain platform and smart contracts, to trade extra energy in the market for Transactive energy, the prosumer initiates trading requests. This research then presented a Weighted Scoring Technique for energy trading. Here, a smart contract saves time-consuming consensus by enabling a node to communicate with other nodes directly without going via the blockchain. Additionally, this study suggested a DPOS in which complete nodes confirm the accuracy of blocks they receive from other nodes in the network. Additionally, it attests to the block's legitimacy and permits its addition to the chain. It seeks to decrease how many people take part in the consensus-building process to boost efficiency then scalability.

Delegates and Stakeholders: In a DPOS system, stakeholders within the blockchain system have the power elect limited amount of delegates or witnesses who will be responsible for validating transactions and creating blocks. Elected delegates take turns to produce blocks in a deterministic and scheduled manner. Each delegate has a specified time slot during which they are authorized to create a block. These blocks contain verified transactions and are added to the blockchain. Delegates must validate the transactions to ensure their accuracy before proposing blocks.

Once a delegate creates a block, it is broadcast to the network for verification by other delegates. Other delegates in the network validate the block to ensure its accuracy and compliance with the consensus rules. Consensus is achieved when a supermajority of delegates (or a predetermined threshold) validate and agree on the validity of block. The unit is appended following verification, to the blockchain.

Then, we store current energy levels and update prices. Hence, the consumers purchase the energy and communicate with the smart contract. Here, the consumer could calculate a score for each prosumer using a weighted average considering both energy availability and price. This method weighs both energy availability and price, favoring prosumers offering more energy at a relatively lower price.

Calculate a score for each prosumer based on a price-weighted metric considering both the price and energy availability. The consumer can define a score according to the energy available and the value offered. Aimed at instance, calculate a score for each prosumer as:

Score_Prosumer_A = Energy_A * (1 / Price_A)

Score_Prosumer_B = Energy_B * (1 / Price_B)

Score_Prosumer_C = Energy_C * (1 / Price_C)

Where Energy_Xthe energy is available with Prosumer X, and Price X is the price offered by Prosumer X.

The consumer selects the prosumer with the highest score as the best choice for trading energy. This method weighs both energy availability and price, favouring prosumers offering more energy at a relatively lower price. It calculates a score for each prosumer based on this criterion, allowing the consumer to select the prosumer with the highest score as the best option. After the selection of suitable prosumers, the consumers started transactions. All completed transactions, including timestamps, energy quantities, prices, and participant addresses, are recorded as immutable entries on the blockchain.

3.4 Profit Generation based on active pricing mechanism

The primary motivator for Profit generating is the incentive for consumers to engage in suggested P2P energy trade. As a result, this research presented Profit Generation, which is based on an active pricing mechanism and will generate profit for both alike. It proposes to use a dynamic pricing method to increase profits for both consumers and prosumers. It adjusts the price according to the balance of incoming and outgoing energy.

The suggested approach defines the time window for executing energy trades at a specific price as hourly. Three scenarios determine energy trading prices:

Situation 1: This situation represents the state in which demand and all available excess energy are equal. ($\xi_{n,s} = \xi_{n,d}$). In other words, because P2P trading generates little profit, customers who engage in it will not exchange energy with electric utility suppliers. P2P transaction costs are determined in this way:

$$\Omega_c = \Omega_p = \frac{\omega_{g,c}+\omega_{g,p}}{2} \quad (14)$$

Situation 2: In this case, there is more available surplus energy than there is demand overall. ($\xi_{n,s} > \xi_{n,d}$). Put another way, prosumers can trade some of their energy with other customers or the electric utility provider in addition to giving energy to those in need by engaging in P2P interchange. The buy price for trading in this case determined as follows:

$$\Omega c = \frac{\omega_{g,c}+\omega_{g,p}}{2} \quad (15)$$

However, the price of the sale of vitality for the utility company is computed in the following manner:

$$\Omega_p = \frac{\Omega_p \sum_{n\epsilon\eta_c} \xi_{n,d} + \omega_{g,c} C_S}{\sum_{n\epsilon\eta_p} \xi_{n,s}} \quad (16)$$

Situation 3: The whole accessible there is less surplus energy than the entire demand. ($\xi_{n,s} < \xi_{n,d}$). Stated differently, if customers engage in peer-to-peer trading, they won't be able to provide the demand of customers who are having power outages, which will compel them to either increase their energy production or request that the customer buy their energy directly from the utility companies.

Profit generating is a necessary component for customers and clienteles to engage in the suggested trading paradigm. As a result, the suggested scheme is meant to be lucrative for prosumers and customers alike. It proposes use of a dynamic pricing method to increase profits for both consumers and prosumers. Smart contracts on the blockchain network contain predefined rules and logic to execute dynamic pricing based on the obtained data. These algorithms execute the pricing adjustments autonomously, removing the need for manual intervention. Here, the dynamic pricing function adjusts the price based on the balance between incoming and outgoing energy.

Finally, EnergyIn > EnergyOut (more supply than demand), could decrease the price. If EnergyOut > EnergyIn (more demand than supply), it could increase the price. Moreover, the energy in = energy out, (demand = supply). It provides the same price.

4. Results And Discussion

This unit analyzes the result of the experiment that led to the proposed Decentralized Energy Trading Framework via Block-chain Smart Contracts.

Tool :PYTHON 3

OS :Windows 7 (64 bit)

Processor: Intel Premium

RAM : 8GB RAM

4.1 Performance results

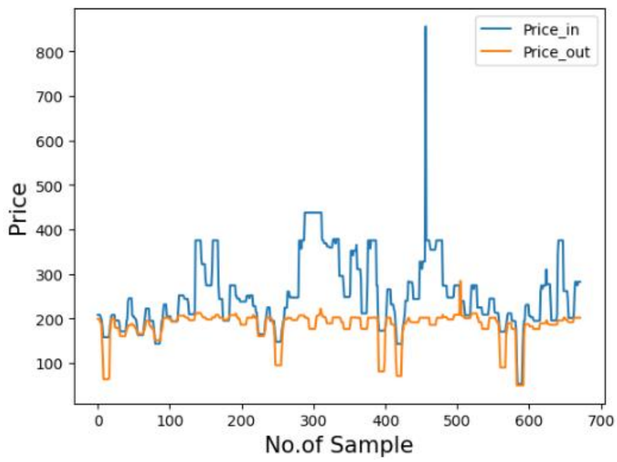

Fig. 5. Price vs Number of Sample

The x-axis often indicates the independent variable in a chart. The total amount of tests is the dependent variable, and it is displayed on the y-axis. Price in represents the prices at which assets or tokens are entering the blockchain. Then, the price out represents the prices at which assets or tokens are leaving the blockchain. Peaks in Figure 5 indicate points where a significant number of transactions occurred.

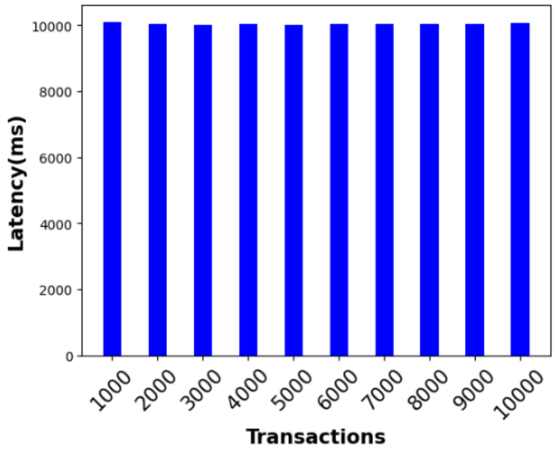

Fig 6. Latency in Blockchain

Latency is defined as the time between the start of a procedure and its completion. Transactions in a blockchain context represent the transfer or modification of data that is recorded on the blockchain. Lower latency allows for faster transaction confirmations and, consequently, a higher throughput. As the amount of transactions rises, our blockchain system maintains a latency hence we reduce the scalability issues.

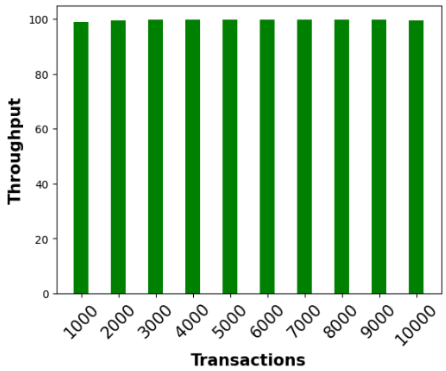

Fig 7. Throughput in blockchain

Throughput is a measure of the capacity of a system to process a certain amount of work within a given time frame. Input is frequently used in blockchain to refer to how many transactions a blockchain network can process at once per unit of time, commonly measured in transactions per second (TPS). Throughput and the number of transactions are directly related. Higher throughput means the blockchain network can process a larger number of transactions in a given time frame.

4.2 Comparison Analysis

The following unit equates the suggested technique with baseline approaches, such as clique, IBFT, PoW, and Raft.

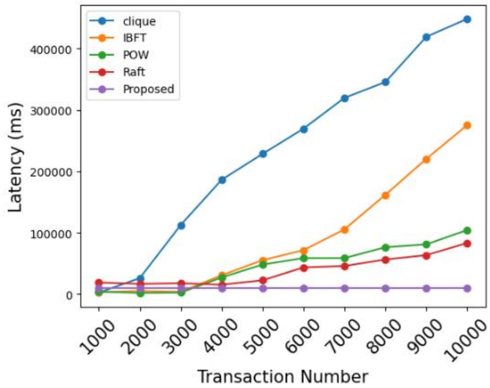

Fig. 8. Comparison of Latency

Figure 8 demonstrates the latency of the proposed strategy. The proposed strategy reduces latency using the provided approach. In comparison to the baseline clique, IBFT, PoW, and Raft, our proposed technique yielded 0.52%, 0.48%, 0.48%, 0.54%, 0.63%, 0.59%, and 0.65%. The latency of the proposed technique is 0.846%. Thus, our proposed approach surpasses existing solutions.

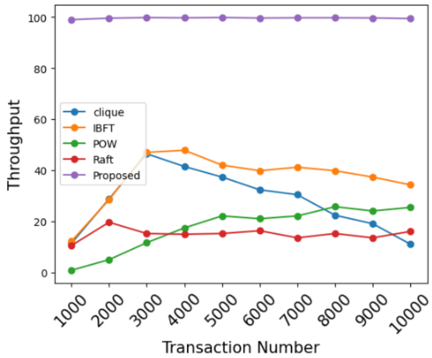

Fig. 9. Comparison of Throughput

Figure 9 shows the proposed methodology. The suggestion being made technique increases the throughput by the planned approach. Our recommended approach is compared to the baseline. clique, IBFT, PoW, and Raft such as 0.52 %, 0.48 %, 0.48 %, 0.54 %, 0.63 %, 0.59 %, and 0.65 %. The throughput of the proposed approach is 0.846 %. Therefore, the suggested method outdoes the current techniques.

5. Conclusion

This research proposed a novel Decentralized Energy Trading Framework via Block-chain Smart Contracts. Initially, we obtain a dataset, and then a concatenated approach is proposed to generate private and public keys which enhances the security and efficiency of this framework., this research proposed a Weighted Scoring Technique for energy trading, here Using a smart contract and a decentralized blockchain network, the sends trade appeal to trade extra vigor in the Transactive energy market. Here, a smart contract allows a node to communicate messages to other nodes without passing through the blockchain, which saves time on consensus. Moreover, this research proposed a Deputized Proof of Stake (DPOS) here full nodes verify the integrity of blocks received from the other nodes in the network. It aims to increase scalability and efficiency by lowering the quantity of people consensus process. Moreover, consumers could calculate a score for each prosumer using a weighted average considering both energy availability and price. Moreover, this research proposed Profit Generation based on an active pricing mechanism that will produce profit for both consumers and users.

DECLARATIONS

Ethics approval and consent to participate

This article does not contain any studies with human participants or animals performed by any of the authors

Consent for publication

All contributors agreed and given consent to Publication.

Availability of data and material

Data that has been used is confidential

Competing interests

On behalf of all authors, the corresponding author states that they have no competing interest.

Funding

No fund was received for this work

Authors' contributions

The authors confirm contribution to the paper as follows and all authors reviewed the results and approved the final version of the manuscript.

First author (Corresponding author): Garima Gurjar Writing original draft, Methodology, study conception and design, analysis and interpretation of results, Reviewing and editing

Second author: Mangesh D.Nikose

Conceptualization, data collection, Reviewing and editing

References

[1] N. Farrar-Foley, N. A. Rongione, H. Wu, A. S. Lavine, & Y. Hu, "Total solar spectrum energy converter with integrated photovoltaics, thermoelectrics, and thermal energy storage: System modeling and design,"Int. J. Energy Res, vol. 46, pp. 5731–5744. 2022.

[2] T. AlSkaif, J. L. Crespo-Vazquez, M. Sekuloski, G. van Leeuwen, & J. P. S. Catalao, "Blockchain-Based Fully Peer-to-Peer Energy Trading Strategies for Residential Energy Systems," IEEE Trans. Ind. Inform, vol. 18, pp. 231–241. 2022.

[3] D. M. Lopez-Santiago, E. Caicedo Bravo, G. Jimenez-Estevez, F. Valencia, P. Mendoza-Araya, & L.G. Marin, "A novel rule-based computational strategy for fast and reliable energy management in isolated microgrids,".Int. J. Energy Res., vol. 46, pp. 4362–4379. 2022.

[4] D. M. Lopez Gonzalez, & J. Garcia Rendon, "Opportunities and challenges of mainstreaming distributed energy resources towards the transition to more efficient and resilient energy markets," Renew. Sustain. Energy Rev, vol. 157, pp. 112018, 2022.

[5] H. Hui, P. Siano, Y. Ding, P. Yu, Y. Song, H. Zhang, & N. Y. Dai, "A Transactive Energy Framework for Inverter-based HVAC Loads in a Real-time Local Electricity Market Considering Distributed Energy Resources," IEEE Trans. Ind. Inform, 2022.

[6] M. Khorasany, A. Shokri Gazafroudi, R. Razzaghi, T. Mostyn, & M. A. Shafie-khah, "framework for the participation of prosumers in peer-to-peer energy trading and flexibility markets," Appl. Energy, vol. 314, pp. 118907. 2022.

[7] A. Paudel, L. P. M. I. Sampath, J. Yang, & H.B. Gooi, "Peer-to-Peer Energy Trading in Smart Grid Considering Power Losses and Network Fees," IEEE Trans. Smart Grid, vol. 11, pp. 4727–4737, 2020.

[8] C. Zhang, J. Wu, Y. Zhou, M. Cheng, & C. Long, "Peer-to-Peer energy trading in a Microgrid," Appl. Energy, vol. 220, pp. 1–12, 2018.

[9] M.S. Javadi, A. Esmaeel Nezhad, A. R. Jordehi, M. Gough, S. F. Santos, & J. P. Catalão, "Transactive energy framework in multi-carrier energy hubs: A fully decentralized model", Energy, 238, pp. 121717. 2022.

[10] N. Liu, X. Yu, C. Wang, C. Li, L. Ma, & J. Lei, "Energy-Sharing Model With Price-Based Demand Response for Microgrids of Peer-to-Peer Prosumers" IEEE Trans. Power Syst, vol. 32, pp. 3569-3583, 2017.

[11] "A game theoretic approach for peer-to-peer energy trading," Energy Procedia, vol. 159, pp. 454–459, 2019.

[12] A. Dorri, A. Hill, S. Kanhere, R. Jurdak, F. Luo, & Z. Y. Dong, "Peer-to-Peer EnergyTrade: A Distributed Private Energy Trading Platform," In Proceedings of the 2019 IEEE International Conference on Blockchain and Cryptocurrency (ICBC), Seoul, Korea, 14–17, pp. 61–64. May 2019.

[13] S. Seven, G. Yao, A. Soran, A. Onen, & S.M. Muyeen, "Peer-to-Peer Energy Trading in Virtual Power Plant Based on Blockchain Smart Contracts," IEEE Access, vol. 8, pp. 175713-175726. 2020.

[14] A. Kumari, D. Vekaria, R. Gupta, & S. Tanwar, "Redills: Deep learning-based secure data analytic framework for smart grid systems," In Proceedings of the 2020 IEEE International Conference on CommunicationsWorkshops(ICCWorkshops), Dublin, Ireland, 7–11 0, pp. 1–6, June 2022.

[15] E. Sorin, L. Bobo, & P. Pinson, "Consensus-Based Approach to Peer-to-Peer Electricity Markets With Product Differentiation," IEEE Trans. Power Syst., vol. 34, pp. 994–1004. 2018.

[16] M. Zhang, F. Eliassen, A. Taherkordi, H. A. Jacobsen, H. M. Chung, & Y. Zhang, "Energy Trading with Demand Response in a Community-based P2P Energy Market," In Proceedings of the 2019 IEEE International Conference on Communications, Control, and Computing Technologies for Smart Grids (SmartGridComm), Beijing, China, 21–23; pp. 1–6, October 2019.

[17] R. Khalid, N. Javaid, S. Javaid, & M. Imran, N. Naseer, "Blockchain-based decentralized energy management in a P2P trading system," In Proceedings of the ICC 2020—2020 IEEE International Conference on Communications (ICC), Dublin, Ireland, 7–11, pp. 1–6, June 2020.

[18] J. Kang, R. Yu, X. Huang, S. Maharjan, Y. Zhang, & E. Hossain, "Enabling Localized Peer-to-Peer Electricity Trading Among Plug-in Hybrid Electric Vehicles Using Consortium Blockchains. IEEE Trans," Ind. Inform, 13, pp. 3154–3164, 2017.

[19] A. Kumari, S. Tanwar, S. Tyagi, N. Kumar, R.M. Parizi, & K. K. R. Choo, "Fog data analytics: A taxonomy and process model. J. Netw. Comput. Appl," 2019, vol. 128, pp. 90-104.

[20] "A motivational game-theoretic approach for peer-to-peer energy trading in the smart grid," Appl. Energy, vol. 243, pp. 10–20, 2019.

[21] V.D. Pham, C.T. Tran, T. Nguyen, T.T. Nguyen, B. L. Do, T.C. Dao, & B.M. Nguyen, "B-Box—A Decentralized Storage System Using IPFS, Attributed-based Encryption, and Blockchain," In Proceedings of the 2020 RIVF International Conference on Computing and Communication Technologies (RIVF), Ho Chi Minh City, Vietnam, 14–15, pp. 1–6, October 2020.

[22] K. Kaur, G. Kaddoum, & S. Zeadally, "Blockchain-Based Cyber-Physical Security for Electrical Vehicle Aided Smart Grid Ecosystem," IEEE Trans. Intell. Transp. Syst., vol. 22, pp. 5178–5189, 2021.

[23] A. Kumari, S. Tanwar, S. Tyagi, & N. Kumar, "Verification and validation techniques for streaming big data analytics in Internet of things environment," IET Netw., 8, 92–100, 2018.

[24] T. Liu, X. Tan, B. Sun, Y. Wu, X. Guan, & D. H. K. Tsang, "Energy management of cooperative microgrids with P2P energy sharing in distribution networks," In Proceedings of the 2015 IEEE International Conference on Smart Grid Communications (SmartGridComm), Miami, FL, USA, 2–5; pp. 410–415, November 2015.

[25] "Smart contract architecture for decentralized energy trading and management based on blockchains," Energy, vol. 199, pp. 117417. 2020

[26] P. Wongthongtham, D. Marrable, B. Abu-Salih, X. Liu, & G. Morrison, "Blockchain-enabled Peer-to-Peer energy trading. Comput. Electr. Eng," vol. 94, pp. 107299, 2021.

[27] "Peer-to-peer energy sharing with battery storage: Energy pawn in the smart grid," Appl. Energy, 297, pp. 117129, 2021

[28] M. Mehdinejad, H. Shayanfar, & B. Mohammadi-Ivatloo, "Decentralized blockchain-based peer-to-peer energy-backed token trading for active prosumers" Energy, vol. 244, pp. 122713–122731. 2022.