

# A Secure and Scalable Framework for Decentralized Data Storage and Trading Using Blockchain and Edge Computing

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**Abstract:** With the proliferation of mobile devices such as smart phones, tablets, and laptops, consumers are creating and sharing large amounts of multimedia information such as images, videos, and documents. Traditional centralized systems have significant risks on data privacy and often share an unequal share of revenue with the intermediaries, which requires the creation of a secure, decentralized data trading and storage system. This paper presents a blockchain-based edge computing platform that leverages high capacity relay nodes to store encrypted and tamper-proof data to enable quick processing and maximize revenue to the data producers. A Rounding-based Data Placement Algorithm (RDPA) is a useful tool to locate cost-effective relay nodes to minimize storage and transmission costs, and a sustainable consensus mechanism, Proof-of-Data-Trading (PODT), is a synthesis of Proof-of-Work and Proof-of-Stake to safely publish blocks with the minimum use of energy. A set of encrypted data is stored on relay nodes and kept within a certain timeframe, and the metadata and location are recorded on the blockchain, which enables safe and open transactions between producers and consumers. Smart contracts make it possible to automate the data transaction, access, and verification process. A compression method is used to reduce the size of the large data items to make the most out of the relay nodes. The proposed solution will ensure decentralized storage of data in a way that is scalable, secure, and cost-effective which will enable the producers to support massive revenue potential and consumers to reliably retrieve data within a blockchain-based edge architecture.

**“Index Terms:** Blockchain, Edge Computing, Data Trading, Smart Contracts, RDPA, PoDT, Data Encryption, Decentralized Storage”.

## 1. INTRODUCTION

With the advent of fifth-generation (5G) communication networks and the growth of the Internet of Things (IoT), edge computing is now a disruptive technology that can be used to meet the growing demands of low-latency, high-throughput data processing. Modern smart gadgets, including unmanned aerial vehicles (UAVs), autonomous vehicles, intelligent sensors and mobile terminals, are generating unprecedented amounts of various types of data. With the integration of edge computing, it becomes easier to perform data processing and make decisions on the edge of the data sources, hence reducing latency and enhancing the efficiency of services in various applications, including smart cities, healthcare, and industrial automation [3]. With the continued development of these devices, sharing, trading, and exploiting data among distributed nodes

has become a major issue of concern in the future of the IoT ecosystem.

Traditional data trading systems heavily rely on third party systems of transaction, user, and payment that are centralized. Despite the fact that that platforms such as as content-sharing service and cloud based market can enable interaction between data producers and consumers, they have their own weaknesses in terms of scalability, trust, and privacy [4]. Intermediaries are often centralized, charge high transaction costs, have an influence on pricing mechanisms and expose players to vulnerability of security and reliability [5]. In addition, when the edge context is widely distributed, resource-constrained devices cannot meet the CPU and communication requirements of centralized data management solutions [6]. So, there is an urgent need of a decentralized, open, and efficient system that will

enable the secure sharing and trading of data between various edge nodes without reliance on intermediaries [7].

This study intends to design a decentralized data transaction system integrating the blockchain technology with edge computing to support the transmission of data in a trustless, auditable and cost-effective manner [8]. The proposed approach is concerned with safe data transmission between the producers, relays, and consumers in a distributed system; it encourages equitable income sharing and reduces the cost of operation. The immutable registry and intelligent contracting of blockchain are used to maintain accountability and automate the transactions between the mistrusted parties. The framework emphasizes efficient placement of data and relaying of the data to minimize latency and communication cost between heterogeneous devices thereby enhancing the overall efficiency of edge-based data exchange systems.

The paper is relevant because it has the potential to revolutionize data management and monetization in decentralized edge networks. The proposed solution enhances transparency, efficiency of resource utilization and allows data creators to have more control over their digital assets by reducing the power of centralized authorities [10]. Moreover, edge computing with blockchain implementation can improve the sustainability, security, and scalability of IoT ecosystems. This study is a pivotal step towards autonomous, distrustful and energy saving data markets that are suited to next generation intelligent networks.

## 2. LITERATURE REVIEW

The last studies have investigated blockchain-based edge computing models to achieve efficient data management, location, and transaction. Wang et al. [11] created a security and time-aware data placement policy in dynamic fogs, which maximizes the security guarantee and service delay tradeoff. Their algorithm was able to maximize the performance of the systems but lacked the flexibility to allow incentive-based and decentralized trading of data. Similarly, Okegbile et al. [12] investigated the effectiveness of blockchain-supported data-sharing models within cloud-edge IoT systems, and they found that the data integrity and access-control improved. However, they assumed the

existence of unchanging network topologies and did not consider the ability of edge devices to vary, which limited scalability in dynamically changing IoT settings.

Zhang [13] proposed a reputation-based method of processing transactions in blockchain networks, which enhances fairness and reliability among mistrusted nodes. Although reputation methodology minimized the bad activity, it also generated a lot of computational and communication overhead which is unsuitable in resource constrained edge devices. Yuan [14] introduced CSEdge, a blockchain-based collaborative storage system, which is used in multi-access edge computing and enables decentralized storage and enhances data availability. Despite its novelty, the system was limited by the reliance on fixed resource allocation algorithms, which limited its cost-efficiency in the conditions of a man-varying workload. Together with these studies, blockchain-assisted edge computing was advanced; however, these studies did not comprehensively tackle how data placement and transaction efficiency can be optimized among the distributed nodes.

Later studies have analyzed the allocation of resources and consensus mechanism that are applicable to edge-based blockchain environments. The article by Huang et al. [15] explored the concept of blockchain consensus and resource allocation in pervasive edge computing and devised methods of optimizing computational load and energy consumption. Their model, however, failed to take into consideration the economic incentives that are necessary to sustain the long-term data trading between edge nodes. Gao et al. [16] proposed an online system that integrates the network selection and service placement in mobile edge computing, and improves the workload offloading and resource utilization. However, their strategy failed to include blockchain-based trust system that is needed to trade data in a secure and autonomic manner. Zhou et al. [17] developed a service-based resource allocation model of blockchain-enhanced edge computing, with a focus on the service performance and system throughput; however, their model poorly considered the minimization of transaction costs and dynamic pricing policies of data marketplaces.

Incentive and consensus optimization have been investigated in recent studies in order to enhance blockchain performance in edge networks. Huang et al. [18] devised an incentive distribution scheme of hybrid consensus systems, which improves participation and stability in decentralized environments. However, their strategy was not particularly focused on low-cost data transactions and adaptive data relay selection. Fan et al. [19] proposed the DR-BFT, a multi-layer blockchain consensus algorithm, which is aimed at ensuring data integrity in dynamic edges systems. This increased reliability, but added an overhead of communication, unsuitable in the lightweight IoT applications. Yang et al. [20] developed delay-sensitive virtual network functionality placement algorithm to pursue a better performance of routing in edge clouds, minimizing latency but ignoring economic and transactional aspects that are relevant to decentralized data markets.

### 3. MATERIALS AND METHODS

The proposed system will bring into the picture a blockchain-based edge computing architecture that targets to enable the trading and storage of data in a safe, transparent, and cost-effective manner. The user generated information including multimedia and document files is ciphertext and is processed through an effective workflow that ensures privacy and decentralized management across the board without making use of centralized cloud servers. A Rounding based Data Placement Algorithm (RDPA) is applied to the selection of the economically efficient relay nodes, which reduces the transmission as well as storage overhead and ensures the optimal system performance. Compression of information is used prior to the location of relays to enhance efficiency in terms of storage so that the storage space can be utilized optimally and more data can be stored. Smart contracts programmed in Solidity with blockchain technology ensure that records of transactions are not changed and data access and payment processes are implemented automatically. Proof-of-Data-Trading (PoDT) consensus is a combination of Proof-of-Work and Proof-of-Stake, enabling secure energy-efficient block production that is suitable when edge devices have limited resources. The system offers a decentralized, reliable and scalable solution to effective data management in edge computing environments.

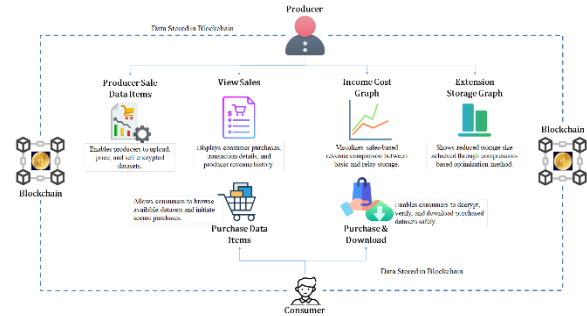


Fig.1 Proposed Architecture

The system architecture is a hybrid of blockchain technology and edge computing to provide the decentralized, secure, and efficient exchange of data. The user generated information is encrypted, compressed and stored in the cost effective relay nodes which are selected through Rounding-based Data Placement Algorithm (RDPA). Blockchain maintains immutable records of the transactions and metadata, whereas smart contracts allow data sales, access, and verification to be automated. The Proof-of-Data-Trading (PoDT) consensus ensures a block creation that is energy-efficient. This architecture is used to ensure transparency, reduce the cost of operation, and enable scalable, privacy-conforming data management in distributed edge environments.

#### a) Modules:

**New User Sign-Up:** In this module, the producers and consumers enroll themselves by filling in the following credentials; username, contact number, email, password and type of user. This information is encrypted and stored in the blockchain by the system and ensures that identity is not manipulated. Such decentralized registration guarantees reliable authentication, prevents illegal access and facilitates easy participation in future data trading and transactional actions in the blockchain-based edge computing model.

#### i) Producer:

**Producer Login:** The producers confirm their identity by keying in their registered usernames and passwords to get secure access to the site. After successful authentication, the users are allowed to add, sell, and work with data objects, view transaction history, and track income and cost indicators. The authentication system is built upon blockchain, ensuring the confidentiality of the data, integrity, and traceability,

which will ensure a secure and customized user experience to the producers in the decentralized data trade environment.

**Producer Sale Data Items:** Using this module, the producers have the opportunity to post and sell their data, which includes information about it like description, pricing, and the data file. The uploaded information is encrypted and stored on cost-effective relay nodes and metadata is recorded on the blockchain. The process guarantees safe, open, and traceable data transfers, which provides producers with the opportunity to sell their data safely and effectively in the decentralized edge network.

**View Sales:** Manufacturers are able to get a review of all the completed sales, including consumer data and bought items. The openness and accountability that this module ensures are ensured by the fact that it maintains the verifiable records of transactions in the blockchain. It helps in making decisions based on data so that the producers can analyze the trends, analyze the sales performance and optimize their plans to achieve greater profitability and interaction in the decentralized market place.

**Income Cost Graph:** This module is a graphical representation of the earnings of producers in correlation to the amount of data sold through an interactive chart. It compares revenue generated in the traditional storage with revenue generated in relay node storage with a focus on cost-effectiveness and improvement in profitability. In the blockchain-based edge computing system, producers can use the analysis of these financial information to make sound decisions about storage methods to maximize returns at minimal operation costs.

**Extension Storage Graph:** The extension storage graph compares the efficiency of the storage of different types of storage with references to the benefits of compressed storage. The relay nodes are able to accommodate more items without reducing the performance due to the minimum size of data. This module demonstrates increased resource efficiency, lower storage costs, and high scalability of sustainable and large-capacity data management in decentralized blockchain-edge computing environments.

#### ii) Consumer:

**Consumer Login:** The decentralized data trade platform allows consumers to access their data through

credentialing and in a safe manner. Once authenticated, users are able to navigate through the data objects that are available, obtain data and download encrypted files. The authentication process based on blockchain ensures the security of verifying identities, protection of privacy, and integrity of the session, which enables the customers to interact safely and confidently with the platform features and data resources.

**Purchase Data Items:** In this module, the user can browse and evaluate the items of data that are available and the information that can be seen are producer name, description, price, size, digital signature and date of upload. It helps in making informed decisions before acquisitions. The data authenticity and transactions transparency of blockchain verification will allow consumers to safely acquire validated, and high-quality data produced by producers in the decentralized market.

**Purchase & Download:** When the customers receive a data item, they will have the opportunity to download the file in its decrypted version in a safe way. The technology authenticates the use of digital signatures and legitimacy of transactions by blockchain, ensuring the integrity of data and secrecy. The module will guarantee privacy in the transmission and avoid unauthorized access, and provide consumers with an opportunity to experience a secure, reliable, and seamless data retrieval process in the decentralized ecosystem.

**Logout (Producer & Consumer):** This module allows the producers and the consumers to have a safe way of finalizing their sessions after use. Leaving the system is a sure way of ensuring that any existing connections are terminated and authentication tokens are invalidated, which prevents unauthorized access. This will maintain the secrecy of user credentials and record of transactions, thus bolstering the security of the system, privacy of data, and the faith that users have in the data trading system based on blockchain.

#### b) Methods/Technologies:

**Blockchain:** Decentralized and unalterable data management by the secure registration of transactions, metadata and relay node data. It eliminates central dependency, ensures transparency, integrity, and trust and supports smart contracts to conduct automated,

traceable, and verifiable transactions of data in dispersed edge environments.

**Smart Contracts:** Automate data deals by checking of credentials, validation of payment and secure access of encrypted data. They ensure consistent execution, prevent disputes, ensure equal distribution of revenues and enhance trust between the players through unalterable and deterministic blockchain systems.

**Rounding-based Data Placement Algorithm (RDPA):** Determines cost effective relay nodes according to the bandwidth, capacity and availability with the aim of cutting storage and transmission costs. It eases the poor positioning, balances the node load, and ensures the best, reliable and scalable data management in decentralized systems.

**Proof-of-Data-Trading (PODT) Consensus:** Combines Proof-of-Work and Proof-of-Stake in order to authenticate blocks safely and with reduced energy usage. It is both integrity-assured, stable, and transparent and allows resource-constrained edge devices to participate in decentralized blockchain operations.

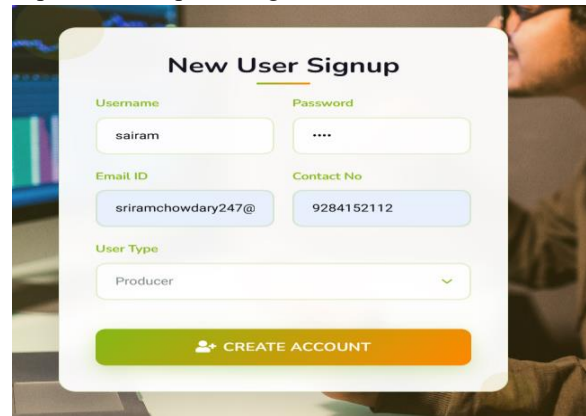
**Data Encryption:** Protect confidential data by encrypting user data before it is stored at the relay node. Only those who are authorized should have the right to decrypt the content, therefore, by ensuring confidentiality, authenticity as well as integrity and prohibiting unauthorized access and alteration during the transmission and storage of the information.

**Data Compression Algorithm:** Reduces file size to increase bandwidth consumption and storage efficiency of relay nodes. It maximizes the storage capacity, saves money, increases the speed of transfer, and enables scalability besides holding the integrity of the information and the credibility of the encrypted content.

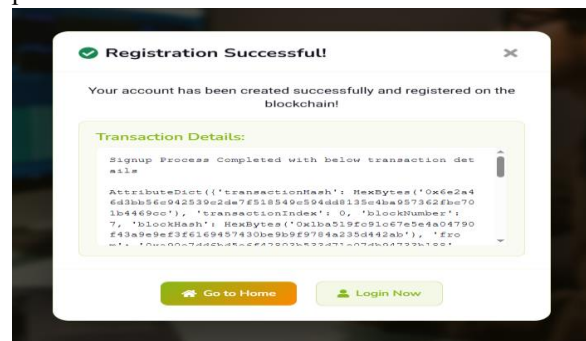
#### 4. EXPERIMENTAL RESULTS



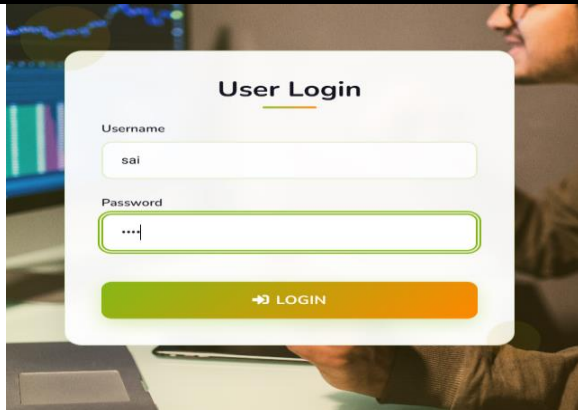
Consequently, the project interface is displayed as depicted in the preceding screen.



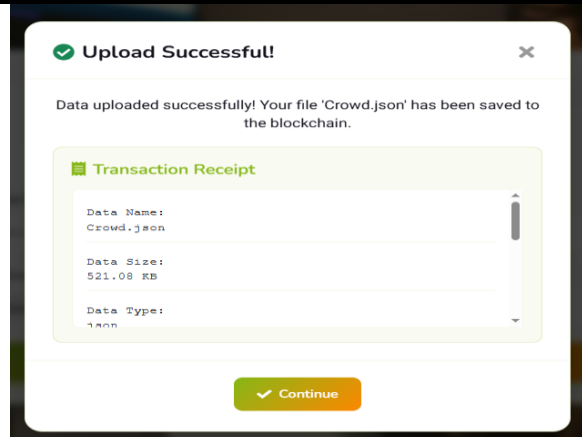
Finalize the registration utilizing the information provided below to guarantee data security for the producer.



The provided information is documented on the blockchain, encompassing relevant transaction details.



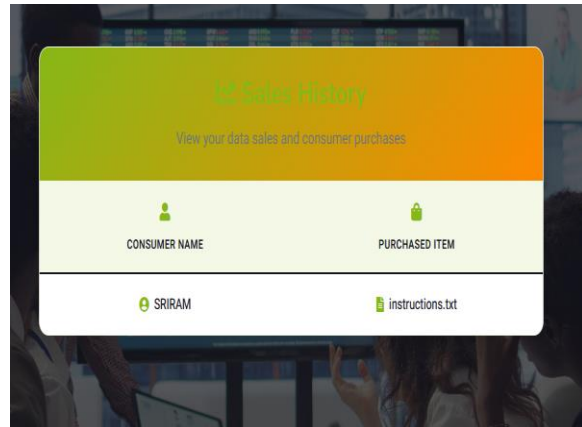
Input your username and password to gain access to the producer account.



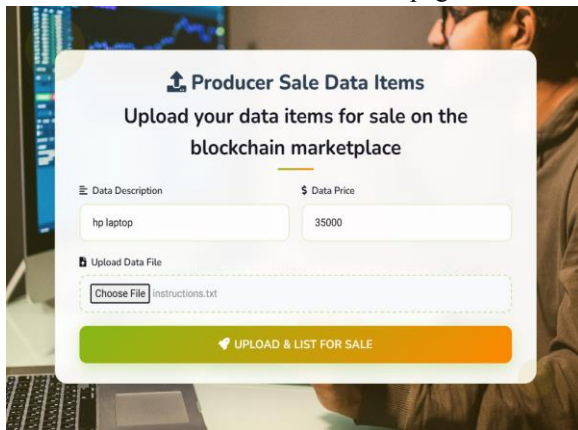
The provided information is documented on the blockchain, encompassing relevant transaction details.



Upon successful login by the producer, the system redirects to the aforementioned home page.



Upon the product's listing on the blockchain, the system presents sales figures and consumer purchasing information.



Submit product or data specifications to the blockchain platform to facilitate sales in the open market.



The graph depicts a comparison of producer ratios across several methodologies.



while ensuring rapid processing speeds. The Rounding-based Data Placement Algorithm (RDPA) enhances the allocation of data items on economical relay nodes, hence minimizing storage and transmission costs. Blockchain maintains metadata and data locations in an immutable ledger, whereas smart contracts executed in Solidity facilitate the automation of data sales, access, and verification procedures. The Proof-of-Data-Trading (PODT) consensus technique integrates Proof-of-Work (PoW) and Proof-of-Stake (PoS) to facilitate safe and energy-efficient block publishing for edge devices. The compression algorithm diminishes data sizes, enhancing relay node efficiency and further lowering storage expenses. Simulation outcomes indicate that producers can effectively sell and monitor data, whereas consumers may securely explore, acquire, and download encrypted data. The solution guarantees secure, scalable, cost-efficient, and high-revenue data trade by integrating blockchain, relay nodes, RDPA, PODT, smart contracts, and compression inside a decentralized edge computing framework.

The future scope of this project encompasses the integration of advanced encryption and privacy-preserving technologies, including homomorphic encryption and zero-knowledge proofs, to augment data security during transactions. The system can be augmented to facilitate multi-relay collaboration and dynamic pricing models for enhanced data trading efficiency. The integration of artificial intelligence can enhance relay selection, forecast data demand, and automate pricing schemes. Furthermore, implementing the system in actual IoT settings and facilitating cross-chain data exchange among various blockchain networks will enhance scalability, interoperability, and functional applicability in decentralized data marketplaces.

#### REFERENCES

- [1] Rashid, S. M., Aliyu, I., Isah, A., Hahn, M., & Kim, J. (2025). Blockchain-Based Task Placement and Resource Management in Edge Computing: A Survey. *Electronics*, 14(17), 3398.
- [2] Cao, Y., Zhao, C., Zhang, Y., & Jin, Y. (2025). Optimizing Resource Allocation and Energy Efficiency in Vehicle Mobile Edge Computing With Blockchain Integration. *IEEE Internet of Things Journal*.
- [3] Matrouk, K. M., Rasappan, P., Bhutani, P., Mittal, S., Nisha, A. S. A., & Konduru, R. M. (2025). Development of Heuristic Strategy With Hybrid Encryption for Energy Efficient and Secure Data Storage Scheme in Blockchain-Based Mobile Edge Computing. *Transactions on Emerging Telecommunications Technologies*, 36(2), e70057.
- [4] Asaithambi, S., Nallusamy, S., Yang, J., Prajapat, S., Kumar, G., & Rathore, P. S. (2025). A secure and trustworthy blockchain-assisted edge computing architecture for industrial internet of things. *Scientific Reports*, 15(1), 15410.
- [5] Pang, S., Tang, Y., Zhai, X., Tong, S., & Wan, Z. (2025). Blockchain-Based UAV-Assisted Mobile Edge Computing for Dual Game Resource Allocation. *Applied Sciences*, 15(7), 4048.
- [6] Nakamoto, S. (2008). Bitcoin: A peer-to-peer electronic cash system. *Decentralized Business Review*, 21260.
- [7] Huang, Y., Zeng, Y., Ye, F., & Yang, Y. (2023). Profit sharing for data producer and intermediate parties in data trading over pervasive edge computing environments. *IEEE Transactions on Mobile Computing*, 22(1), 429–442.
- [8] Naresh, M., Gudditti, M., Viswanath, & SunilKumarReddy, M.T. (2014). Distributed Utility-Based Energy Efficient Cooperative Medium Access Control in MANETS.
- [9] Liu, Y. (2023). A blockchain-based decentralized, fair and authenticated information sharing scheme in zero trust Internet-of-Things. *IEEE Transactions on Computers*, 72(2), 501–512.
- [10] Bao, Y., Peng, Y., & Wu, C. (2023). Deep learning-based job placement in distributed machine learning clusters with heterogeneous workloads. *IEEE/ACM Transactions on Networking*, 31(2), 634–647.
- [11] Wang, X., Veeravalli, B., Song, J., & Liu, H. (2023). On the design and evaluation of an optimal security-and-time cognizant data placement for dynamic fog environments. *IEEE Transactions on Parallel and Distributed Systems*, 34(2), 489–500.
- [12] Okegbile, S. D., Cai, J., & Alfa, A. S. (2022). Performance analysis of blockchain-enabled data-sharing scheme in cloud-edge computing-based IoT networks. *IEEE Internet of Things Journal*, 9(21), 21520–21536.

- [13] Zhang, J. (2022). A reputation-based mechanism for transaction processing in blockchain systems. *IEEE Transactions on Computers*, 71(10), 2423–2434.
- [14] Yuan, L. (2022). CSEdge: Enabling collaborative edge storage for multi-access edge computing based on blockchain. *IEEE Transactions on Parallel and Distributed Systems*, 33(8), 1873–1887.
- [15] Huang, Y., Zhang, J., Duan, J., Xiao, B., Ye, F., & Yang, Y. (2022). Resource allocation and consensus of blockchains in pervasive edge computing environments. *IEEE Transactions on Mobile Computing*, 21(9), 3298–3311.
- [16] Vasagam, M., Kumar, A., & Garg, A. (2026). Learning Execution Plan Embeddings for Multi-Dimensional Query Resource Prediction. *IEEE Access*.
- [17] Zhou, A., Li, S., Ma, X., & Wang, S. (2022). Service-oriented resource allocation for blockchain-empowered mobile edge computing. *IEEE Journal on Selected Areas in Communications*, 40(12), 3391–3404.
- [18] Kalae, U. K. (2021). Enhancing data analytics and reporting efficiency using Power BI and SQL in cloud computing environments. *Journal of Computational Analysis and Applications*, 29(6), 2021. <https://doi.org/10.48047/jocaaa.2021.29.06.48>.
- [19] Poojari, R. (2024). Empirical Analysis of Context Window Enhancement Methods in Retrieval-Augmented Generation Models. *Journal of Computational Analysis and Applications*, 33(2).
- [20] Yang, S., Li, F., Trajanovski, S., Chen, X., Wang, Y., & Fu, X. (2021). Delay-aware virtual network function placement and routing in edge clouds. *IEEE Transactions on Mobile Computing*, 20(2), 445–459.
- [21] Yang, S. (2021). Survivable task allocation in cloud radio access networks with mobile-edge computing. *IEEE Internet of Things Journal*, 8(2), 1095–1108.
- [22] Viswanath, G., Abirami, V., & Prathyusha, G. (2024). Hybrid Feature Extraction With Machine Learning To Identify Network Attacks. *International Journal Of Hrm And Organizational Behavior*, 12(3), 217-228.
- [23] Fang, J. J., & Lei, K. (2020). Blockchain for edge AI computing: A survey. *Journal of Applied Science*, 38(1), 1–21.
- [24] Huang, Y., Zeng, Y., Ye, F., & Yang, Y. (2020). Incentive assignment in PoW and PoS hybrid blockchain in pervasive edge environments. In *Proceedings of the IEEE/ACM 28th International Symposium on Quality of Service (IWQoS)* (pp. 1–10).
- [25] Kuo, T.-T., & Ohno-Machado, L. (2018). Modelchain: Decentralized privacy-preserving healthcare predictive modeling framework on private blockchain networks. *arXiv preprint arXiv:1802.01746*.
- [26] He, H., Yan, A., & Chen, Z. (2018). Survey of smart contract technology and application based on blockchain. *Journal of Computer Research and Development*, 55(11), 2452.
- [27] Lin, X., Li, J., Wu, J., Liang, H., & Yang, W. (2019). Making knowledge tradable in edge-AI enabled IoT: A consortium blockchain-based efficient and incentive approach. *IEEE Transactions on Industrial Informatics*, 15(12), 6367–6378.
- [28] Rose, D. (2019). Nothing at stake in knowledge. *Noûs*, 53(1), 224–247.
- [29] M, Chaithanya., Viswanath, G., Dunna, Nikitha Rao., G, Prathyusha. (2023). A Real Time Online Food Ordering Application Based Django Restfull Framework Juni Khyat journal, 13(9), 154-162.
- [30] Azaria, A., Ekblaw, A., Vieira, T., & Lippman, A. (2016). MedRec: Using blockchain for medical data access and permission management. In *Proceedings of the IEEE International Conference on Open and Big Data (OBD)* (pp. 25–30).