iJRASET
International Journal For Research in Applied Science and Engineering Technology



INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 12 **Issue:** V **Month of publication:** May 2024

DOI: https://doi.org/10.22214/ijraset.2024.62814

www.ijraset.com

Call: 08813907089 | E-mail ID: ijraset@gmail.com

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 12 Issue V May 2024- Available at www.ijraset.com

SupplySphere: Orbting SupplyChain Management with Blockchain and IOT

Dr. Smitha Shekar B[1], Dr. Harish G[2], Krtin U Shet[3], Mahinder Patel[4], Nira Udas[5], Nishanth V[6]
[1, 2]*Associate Professor,* [3, 4, 5, 6]*Student, B.E, Department of C.S.E, Dr. Ambedkar Institute of Technology*

Abstract: ***Conventional supply chain management systems often lack adaptability and visibility, leading to inefficiencies and diminished trust among stakeholders. Supply Sphere presents a novel framework that integrates blockchain technology and the Internet of Things (IoT) to establish flexible and transparent supply chains. This platform enables manufacturers to customize supply chains according to specific products, starting from procurement to final delivery to end-users. Each product is associated with a QR code, granting access to detailed historical data and essential information as required by regulatory bodies. IoT devices within the system are designated unique functions, providing real-time data to smart contracts managed by blockchain. These contracts actively supervise compliance and integrity, halting operations and notifying stakeholders in case of discrepancies or irregularities. These functionalities are especially vital in critical sectors like pharmaceuticals, emphasizing precision and confidence. By streamlining and safeguarding supply chain procedures, Supply Sphere improves operational effectiveness and nurtures a higher level of confidence and dependability throughout all supply chain phases.***
Keywords: Blockchain, Supplychain, IOT, QR code tracking, transparent, integrity, customization

I. INTRODUCTION

Supply chain management (SCM) is a critical component of modern global commerce, challenged by inefficiencies across various industries including pharmaceuticals, electronics, and agriculture. These inefficiencies often manifest as lack of transparency, traceability, and integrity, which can lead to operational delays, increased costs, and compromised product quality. The proposed Supply Sphere platform addresses these challenges by leveraging blockchain technology and Internet of Things (IoT) devices, creating a flexible, secure, and transparent framework adaptable to diverse supply chain needs

In traditional SCM systems, issues such as data silos and centralized control points often lead to inefficiencies and vulnerabilities, including counterfeit products and distribution errors, particularly noted in pharmaceuticals[1]. However, these challenges are not limited to any single sector. For instance, in the agriculture industry, traceability and safety of food products remain paramount, where blockchain can provide transparent tracking of produce from farm to table, enhancing safety and compliance with health regulations [2].

Supply Sphere introduces a blockchain-based system where each transaction within the supply chain is recorded on an immutable ledger, ensuring that all data is reliable and secure. IoT devices integrated into this framework provide real-time monitoring and verification of supply chain processes across multiple industries, enhancing operational efficiency and data reliability. This system's adaptability allows it to be tailored to specific needs of various sectors, from manufacturing electronics with complex parts to managing perishable goods in agriculture, ensuring optimal conditions throughout the supply chain.

Supply Sphere utilizes smart contracts to automate and secure interactions within the supply chain, minimizing human errors and reducing transaction times. This feature is particularly beneficial in industries like automotive manufacturing, where parts and assemblies from various suppliers must be meticulously tracked and integrated[3]. The platform's ability to provide a transparent view of the entire supply chain enhances trust among stakeholders and empowers consumers with information about the origins and handling of the products they purchase.

II. PROBLEM STATEMENT

Supply Sphere seeks to address critical inefficiencies in supply chain management across diverse industries by leveraging blockchain and IoT technologies. This approach aims to overcome several distinct challenges:

1) *Data Integrity and Security:* In SCM systems, maintaining data integrity and security is paramount. Blockchain technology offers an immutable ledger, ensuring that data once entered cannot be altered, thus providing a reliable source of truth for all transactions and interactions within the supply chain.

©IJRASET: All Rights are Reserved

2) *Scalability of Operations:* Traditional SCM systems often struggle to scale effectively with increasing complexity and volume of transactions. Supply Sphere uses blockchain to facilitate scalability by enabling decentralized operations that can handle increased loads without a central point of failure.
3) *Customization and Flexibility:* Different industries require tailored SCM solutions due to varying regulatory and operational demands. Supply Sphere's customizable blockchain framework allows for sector-specific adaptations, ensuring compliance and operational efficiency across diverse markets.
4) *Reduction of Supply Chain Discrepancies:* Misalignments and discrepancies within the supply chain can lead to significant financial losses. By integrating real-time tracking systems through IoT, Supply Sphere enhances the accuracy of data across the supply chain, minimizing discrepancies and improving response times to supply chain disruptions.
5) *Improved Sustainability Practices:* Environmental sustainability is becoming increasingly crucial in supply chain operations. Supply Sphere contributes to sustainable practices by improving resource management and reducing waste through enhanced tracking and efficient resource allocation.
6) *Enhanced Consumer Confidence:* By providing a transparent view of the supply chain, consumers gain insights into product origins and handling processes, which enhances trust and satisfaction. This transparency is crucial for industries where authenticity and ethical sourcing are significant consumer concerns.

III.LITERATURE SURVEY

"The Potential of Blockchain Technology for Safe Supply Chain Management: A Comprehensive Study" [4].
This paper examines blockchain's role in enhancing safety and efficiency in supply chain management (SCM). It identifies key issues such as lack of transparency, traceability, and security in traditional SCM systems. The study suggests blockchain as a viable solution to these problems due to its decentralized and immutable ledger capabilities, which ensure transactional transparency and data integrity. The paper emphasizes blockchain's potential to streamline processes, reduce fraud, and enhance stakeholder confidence, making it suitable for high-stakes industries like pharmaceuticals and luxury goods.

"An Analysis of Blockchain in Supply Chain Management: System Perspective, Current and Future Research"[1].
This research presents a comprehensive analysis of blockchain in supply chain management, discussing its capacity to transform traditional supply chains into more secure, transparent, and efficient systems. The paper outlines key benefits such as reduced fraud, enhanced traceability, and decreased costs, while also considering the current limitations and future potential of blockchain applications in supply chains. The authors advocate for a broader adoption as blockchain technology matures, predicting significant impacts on global supply chain operations.

"A Survey on Blockchain-Based Pharmaceutical Supply-Chain Management and Drug Distribution: The Case of Morocco"[2].
This paper focuses on the pharmaceutical supply chain in Morocco, outlining how blockchain technology can resolve prevalent issues like drug counterfeiting and distribution inefficiencies. The authors provide a quantitative analysis of blockchain applications in this sector, pointing out the increased safety, reliability, and traceability that blockchain offers. The study also discusses the regulatory and adoption challenges specific to Morocco but applicable globally.

"Blockchain as Supply Chain Technology: Considering Transparency and Security"[5].
This paper delves into how blockchain technology can simultaneously improve transparency and security within supply chains, which traditionally face a trade-off between these two critical aspects. It highlights blockchain's potential to enhance the integrity and availability of data while addressing confidentiality challenges, making it a pivotal technology for complex supply networks that span across diverse industries. The study also provides a theoretical model and propositions that forecast future areas of research, emphasizing the blockchain's role in easing tension between the need for transparency and maintaining security.

"IoT-based Supply Chain Management: A Systematic Literature Review"[6]
Taj et al. focus on the integration of the Internet of Things (IoT) in SCM, identifying how IoT can automate and optimize supply chain processes to maximize operational efficiencies and reduce costs. The study fills a knowledge gap by providing a detailed analysis of IoT applications from 2018 to 2022, emphasizing IoT's role in real-time monitoring, asset management, and enhanced data acquisition through various sensors and devices.

"Distributed Interoperable Records: The Key to Better Supply Chain Management"[7].
This paper examines the critical role of Distributed Ledger Technology (DLT) in achieving interoperability across supply chain management (SCM) systems. The authors argue that the lack of interoperability between different record systems and digital platforms functions as a major bottleneck, hindering the efficiency and transparency of global supply chains. By leveraging DLT, the paper proposes a framework that enables seamless exchange and integrity of records across disparate systems, enhancing transparency, reliability, and efficiency in SCM processes. The key benefits highlighted include reduced transaction times, enhanced traceability of products, and improved handling of SCM-related issues like damages and location tracking in real-time. This approach is positioned as a holistic solution to the fragmented nature of contemporary supply chains, which often operate like isolated digital islands.

IV. METHODOLOGY

A. Existing Systems

Both blockchain-based and non-blockchain-based supply chain management systems have been widely implemented to enhance transparency, efficiency, and security. Blockchain-based systems, such as IBM Food Trust, offer significant improvements over traditional systems but also face several challenges. IBM Food Trust leverages blockchain technology to create a trusted environment for food traceability and safety. Participants record transactions on a shared ledger, ensuring transparency and accountability throughout the supply chain. However, the system faces challenges such as high integration costs, the need for extensive training, and interoperability issues with existing legacy systems. Additionally, the scalability of blockchain technology can be a limiting factor as transaction volumes increase. Non-blockchain-based systems, such as SAP Supply Chain Management and Microsoft Dynamics 365, rely on centralized databases and manual tracking processes. SAP's solution integrates various supply chain processes into a unified platform, offering features like inventory management, demand planning, and supplier collaboration. However, centralized control makes the system vulnerable to single points of failure and data tampering. Manual processes and lack of real-time tracking contribute to inefficiencies and increased operational costs. Microsoft Dynamics 365 combines ERP and CRM capabilities to manage supply chain operations, providing robust data analytics and reporting tools. Similar to SAP, this system struggles with centralization issues. Furthermore, the high cost of implementation and maintenance, along with the need for frequent updates and training, pose significant challenges. Centralized supply chain management systems, such as SAP and Microsoft Dynamics 365, face several issues including single points of failure, data tampering, lack of transparency, inefficiencies in data management, limited scalability, high costs, regulatory compliance challenges, and vendor lock-in. These centralized systems rely on a single server or database, making them vulnerable to failures and security breaches, while also struggling with real-time transparency and scalability. SupplySphere addresses these issues by leveraging blockchain and IoT technologies to create a decentralized, transparent, and efficient platform. Blockchain ensures immutable data records and decentralized control, eliminating single points of failure and enhancing security. IoT devices automate data collection, reducing manual errors and costs. The integrated marketplace within SupplySphere streamlines transactions, improves market accessibility, and boosts production rates, providing a comprehensive solution that overcomes the limitations of traditional centralized systems.

B. Proposed System

SupplySphere is an innovative supply chain management system that leverages blockchain and IoT technologies to provide a secure, transparent, and efficient platform for managing supply chains. Unlike existing systems, SupplySphere integrates an online marketplace, enabling suppliers to list and sell their products, raw materials, and services directly.

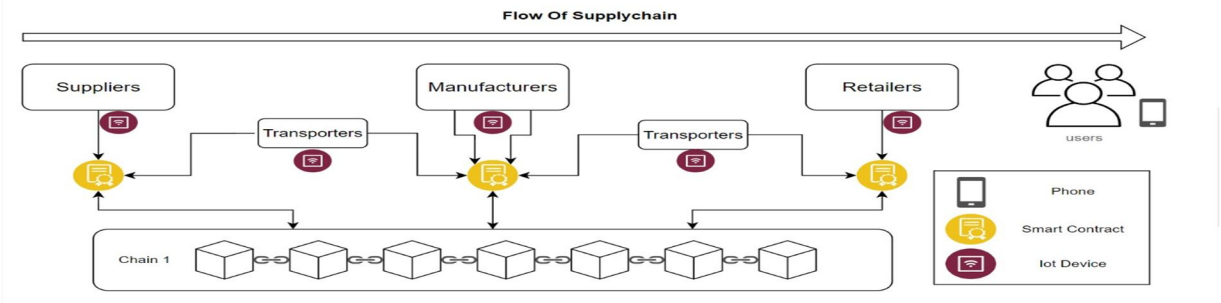


Fig. 1 Flow of Supplychain

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 12 Issue V May 2024- Available at www.ijraset.com

The system flow as shown in Fig.1 begins with suppliers registering their products and services on the platform. Manufacturers then create and manage custom supply chains, specifying the stages from procurement to delivery. Transporters handle the logistics, with each transfer validated through a four-step handshake process. This process includes: (1) Sender Confirm, where the sender confirms the handover to the transporter, (2) Transporter Received, where the transporter confirms receipt of goods, (3) Transporter Delivered, where the transporter confirms delivery to the receiver, and (4) Receiver Confirm, where the receiver confirms receipt of goods. Retailers and end-users can track the entire product history via a QR code.

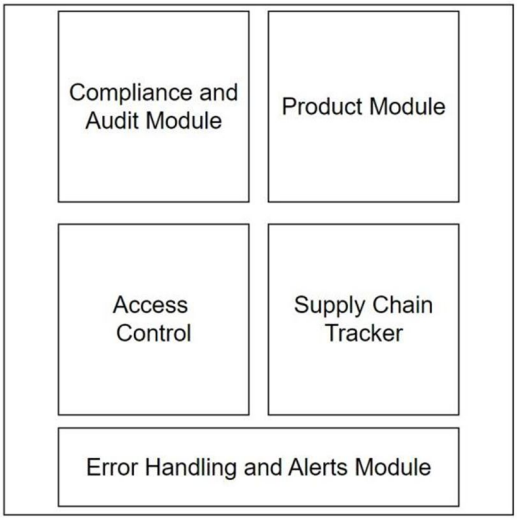


Fig. 2 Structure of Smart Contract

The architecture of SupplySphere's smart contract in Fig.2 comprises several integral modules, each designed to manage specific aspects of the supply chain, ensuring a robust and comprehensive management system.

A. Access Control Module

The Access Control Module manages roles and permissions within the SupplySphere platform, ensuring that only authorized participants can perform specific actions. This module defines various roles such as admin, manufacturer, transporter, retailer, and inspector, each with specific permissions pertinent to their responsibilities. Role assignment functions allow for the dynamic assignment and revocation of roles to specific addresses, providing flexibility and control over access to different functionalities within the platform. To maintain security and integrity, access control checks verify that only authorized roles can execute certain functions, thereby preventing unauthorized access and potential misuse of the system.

B. Supply Chain Tracker Module

Central to the management of the flow of goods and data within the supply chain is the Supply Chain Tracker Module. This module initializes new supply chains by defining the required participants and registering the IoT devices that will monitor and record data. At each stage of the supply chain, IoT devices record relevant data, which is then securely stored within the blockchain. The module verifies this recorded data against predefined tolerance values to ensure accuracy and consistency. Status update functions mark the stages of the supply chain as in-progress, halted, or completed, providing real-time tracking and management of the supply chain's status.

C. Product Module

The Product Module manages the lifecycle of products within the supply chain, from registration to end-user delivery. It registers new products with unique IDs, ensuring they can be individually tracked throughout the supply chain. Each product is linked to a QR code, facilitating easy tracking and access to product history. Functions within this module record and retrieve the complete history of the product, providing transparency and traceability. Additionally, this module manages the raw materials and services provided by suppliers, integrating them into the overall product lifecycle management.

©IJRASET: All Rights are Reserved

D. Error Handling and Alerts Module

Ensuring the integrity of the supply chain, the Error Handling and Alerts Module is designed to detect and manage errors effectively. Anomalies in the data recorded by IoT devices are detected through predefined checks, ensuring any deviations are promptly identified. An alert system notifies stakeholders of any errors or issues, allowing for quick response and resolution. In the event of critical errors, the supply chain process can be paused to prevent further issues. Once resolved, the process can be resumed, ensuring minimal disruption.

E. Compliance and Audit Module

The Compliance and Audit Module ensures adherence to regulatory standards and maintains a transparent audit trail. Regular compliance checks are performed to ensure that all steps within the supply chain adhere to relevant regulatory standards, maintaining legal and industry compliance. Detailed logs of all transactions and changes are maintained, providing an auditable trail that can be reviewed to ensure transparency and accountability.

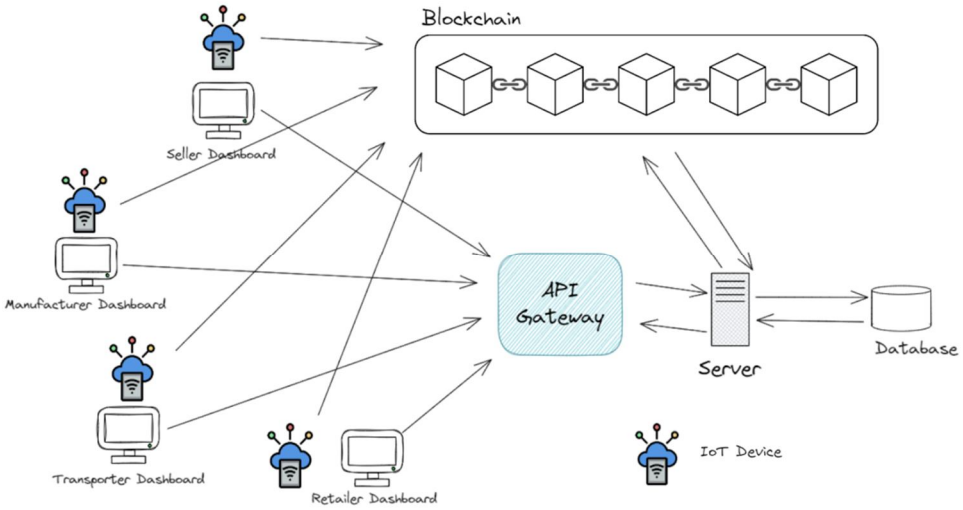


Fig. 1 System architecture diagram

The architecture of SupplySphere shown in Fig.3, consists of several components. The blockchain network utilizes Ethereum for decentralized data storage and smart contract execution. IoT devices are registered on the platform to monitor and record data at each stage of the supply chain. A user-friendly web interface, developed using React.js for the front end and Nest.js for the back end, provides seamless interaction for suppliers, manufacturers, transporters, retailers, and inspectors. Off-chain storage is used for non-critical data to optimize performance and reduce costs.

The process begins with blockchain integration, where smart contracts are deployed on the Ethereum network.Alongside this, IoT devices are set up and registered on the platform. These devices are configured to interact with the smart contracts, providing real-time data on various supply chain parameters such as location, temperature, handling conditions and other critical data defined as per the supply chain. This integration ensures that all critical data is recorded on the blockchain, maintaining the integrity and accuracy of the supply chain information.Web application development focuses on creating a user-friendly interface using modern web technologies like React.js for the front end and Nest.js for the back end. This interface allows participants, including suppliers, manufacturers, transporters, retailers to interact seamlessly with the platform. The web application provides functionalities for managing supply chain activities, accessing data, and interacting with smart contracts. Additionally, the development of an integrated marketplace facilitates direct transactions between suppliers and buyers, reducing the time and costs associated with traditional supply chain operations.

V. RESULTS

The proposed system, SupplySphere, significantly enhances supply chain management by providing transparency, efficiency, security, and market accessibility. Real-time tracking of products and materials through a tamper-proof blockchain ledger ensures transparency. Streamlined processes reduce the need for manual interventions and paperwork, enhancing efficiency. Enhanced data security is achieved through decentralized storage and IoT device monitoring.

The integrated marketplace within SupplySphere is a game-changer for supply chain management. It allows suppliers to list their products, raw materials, and services directly on the platform, enabling them to reach large clients without the need for extensive back-and-forth communication. This reduces the time and effort required for paperwork and negotiations, allowing industries to move faster and more efficiently. By facilitating direct transactions, the marketplace helps small businesses bring their products to market more quickly. Centralizing supply chain management and marketplace operations reduces the need for multiple service subscriptions, cutting down on costs and administrative overhead. Streamlined processes and reduced delays contribute to higher production rates, benefiting both suppliers and manufacturers. The blockchain-based system ensures that all transactions and product histories are transparent and immutable, building trust among all participants.

SupplySphere addresses the limitations of existing systems by integrating supply chain management with a dynamic marketplace, all powered by blockchain and IoT technologies. This comprehensive solution not only improves efficiency and security but also boosts the overall productivity and competitiveness of industries.

VI. FUTURE WORKS AND APPLICATIONS

Future enhancements for SupplySphere will focus on integrating advanced technologies to further optimize the platform's efficiency, user experience, and predictive capabilities. One promising area of development involves adopting the principles outlined in "FLUID: Towards Efficient Continuous Transaction Processing in DAG-based Blockchains." This approach leverages Directed Acyclic Graphs (DAGs) to enable more efficient and scalable transaction processing. By structuring smaller transactions into a hierarchical model, we can streamline the management and execution of these transactions, thereby enhancing the overall throughput and reducing latency. This will be particularly beneficial in handling the high volume of microtransactions common in supply chain operations, ensuring that the system remains responsive and efficient even as the transaction load increases.

Another significant area for future work is the integration of Artificial Intelligence (AI), particularly leveraging Large Language Models (LLMs) for enhanced customer support and predictive analytics. The use of LLMs can provide personalized and efficient customer service, addressing user queries and resolving issues promptly. This AI-driven support will improve user satisfaction by offering immediate assistance and accurate information. Additionally, AI can be employed to analyze vast amounts of supply chain data to predict market trends and immediate demands. This predictive capability will enable better management of warehouses and stock levels, ensuring that inventory is optimized to meet future demands. AI can also assist in identifying potential disruptions in the supply chain, allowing for proactive measures to mitigate risks.

Beyond these advancements, there are other areas where SupplySphere can evolve. Incorporating machine learning algorithms to optimize route planning for transporters can reduce delivery times and costs. Implementing advanced IoT analytics can provide deeper insights into supply chain operations, helping to identify inefficiencies and opportunities for improvement. Enhancing the security protocols with quantum-resistant cryptography can future-proof the platform against emerging threats. Additionally, exploring the integration of decentralized finance (DeFi) mechanisms can offer innovative financial services to participants, such as supply chain financing and insurance. By continuously adopting cutting-edge technologies and methodologies, SupplySphere can maintain its position as a leader in supply chain management solutions, providing a comprehensive, efficient, and secure platform for all stakeholders.

VII. CONCLUSION

SupplySphere represents a transformative leap in supply chain management by integrating blockchain and IoT technologies to overcome the inefficiencies and vulnerabilities of traditional systems. Its decentralized architecture ensures immutable, secure transactions, while IoT devices provide real-time, accurate data, enhancing transparency and reliability. The platform's integrated marketplace accelerates time-to-market and reduces costs by facilitating direct transactions. The overall inclusiveness of the SupplySphere platform allows users to save time by consolidating multiple tools into a single, focused solution. Future enhancements, including DAG-based blockchain structures and AI integration, will further optimize performance and predictive capabilities, ensuring SupplySphere remains a leader in supply chain solutions. Overall, SupplySphere significantly boosts efficiency, security, and trust across diverse industries, positioning it as a pivotal innovation in supply chain management.

REFERENCES

[1] Ray, S., & Peter, G. (2021). An analysis of blockchain in Supply Chain Management: system perspective, current and future research. International Business Logistics.

[2] Znaki, Y., & Enneffah, W. (2023). A survey on Blockchain-based pharmaceutical supply-chain management and drug distribution: The case of Morocco. Colloque sur les Objets et Systèmes Connectés 2023.

[3] Hellani, H., Sliman, L., Samhat, A. E., & Exposito, E. (2021). On blockchain integration with supply chain: Overview on data transparency. Logistics, 5(3), 46.

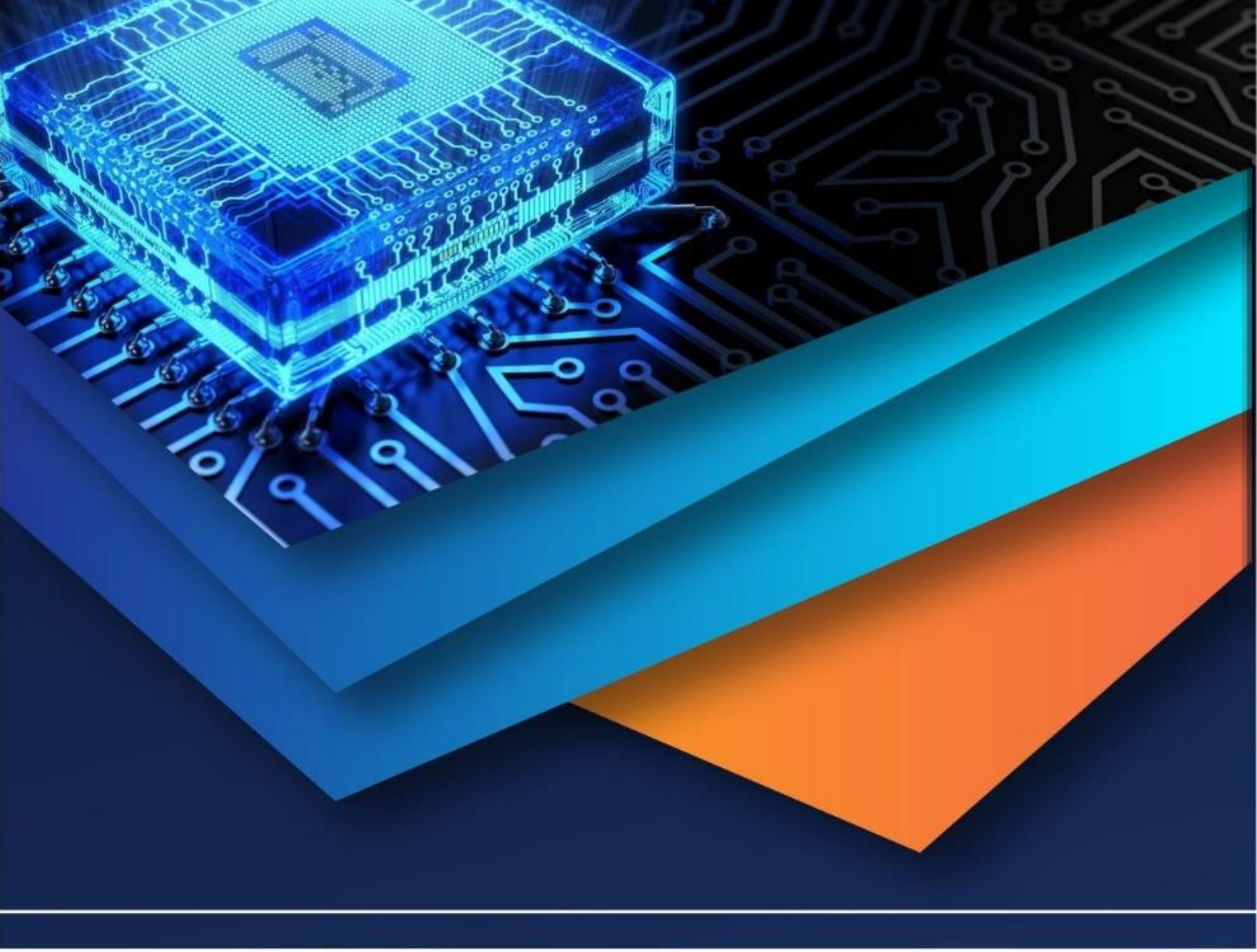
[4] Kamal, M. V., I. Nagaraju, P. Dileep, and P. Revathy. "The Potential of Blockchain Technology for Safe Supply Chain Management: A comprehensive Study." Turkish Journal of Computer and Mathematics Education (TURCOMAT) 14, no. 2 (2023): 824-831.

[5] Xu, Pei, Joonghee Lee, James R. Barth, and Robert Glenn Richey. "Blockchain as supply chain technology: considering transparency and security." International Journal of Physical Distribution & Logistics Management 51, no. 3 (2021): 305-324.

[6] Taj, Soonh, Ali Shariq Imran, Zenun Kastrati, Sher Muhammad Daudpota, Raheel Ahmed Memon, and Javed Ahmed. "IoT-based supply chain management: A systematic literature review." Internet of Things 24 (2023): 100982.

[7] Henninger, Annegret, and Atefeh Mashatan. "Distributed interoperable records: The key to better supply chain management." Computers 10, no. 7 (2021): 89.

©IJRASET: All Rights are Reserved | SJ Impact Factor 7.538 | ISRA Journal Impact Factor 7.894 |



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Call : 08813907089 (24*7 Support on Whatsapp)