International Journal of Emerging Research in Applied Medical Sciences (IJERAMS)

Blockchain and IoT Integration for Secure and Transparent Supply Chain Management

Athram Mahesh
bhaskar medical college,telangana,india
athrammahesh@gmail.com

ABSTRACT

Even the tone of proposing the idea of Internet of Things (IoT) to the supply chain management process has already made quite a difference in the sense of promising a more efficient process in the operations process, inventory management and actual tracking of various goods in real time. But with regards to data security, data privacy and data transparency of the data, the question of the data appears in the case of IoT system in the supply chain. The block chain technology has been one of the solutions to such issues as it is an immutable transparent and decentralised technology. As it is a collaborative process, data integrity, traceability, transparent and secure transaction along the supply chain with use of IoT and the Blockchain can be contributed even by the organization. The paper has raised the issue of the combination of the Blockchain and IOT into the supply chain management especially its secure and transparent supply chain management and how blockchain can be used as a means of mesh-up of exchanges, the provenance of products and security of regulatory compliance. The condition of the application of the IoT devices in the context of the data collection and data transfer and the method that Blockchain can be employed in the context of the security of the collected data and its real-time transparency is also stated in the paper. The case studies and simulation represented by the document demonstrate that, it is possible to combine both Blockchain and IoT in a bid to enhance an effectiveness of the operations, and eliminate frauds, as well as allow general visibility of the supply chain. It also looks through the problems that are stepped on along with the implementation of such collective actions, and it is basing on it that answers are given to the questions on how to win the problems.

Keywords: ***Block chain, IoT supply chain controls, information Security, transparencies.***

DOI: https://doi.org/10.65477/ijerams.v1.i2.02

1. Introduction

Through such an integration, it is able to check the origin of products, and taps into its supply chain, which determines cost, quality, speed and dependability, risk-reducing, sustainability and flexibility (Bhadoria et al., 2020) (Hellani et al., 2021). The integration of the Blockchain and the IoT provides security, trace and speed to its supply chain that is challenged by the issue of the safety of the data, interoperability and expensive implementations (Mircea et al., 2022) (Sallam et al., 2023). The integrity of the data in the IoT devices will be supported by blockchain, via a secured ledger, which will enable quality of the items in a chain of transport or even supply chain management, medical aspect and even information about the environment (Hassan et al., 2024). It will

bring the discussion that the use of IoT is remarkable in the new systems of supply chain because it deals with the real time presence, automation and data management which are extremely important in the ideal systems of operations.

Nevertheless, there are certain threats that are associated with the states of data security or probity and transparency of the IoT networks. Decentralized ledger system in blockchain can attain the potentiality of providing the solutions which would reveal and experience safe transactions on the supply chain that has been provided by the IoT. It is also going to identify the scope of the study of IoT and Blockchain integration in the given section and list the improvement of the supply chain transparency, accountability, and security as the most likely benefits of such one (Khordadpour and Ahmadi, 2024) (Singh et al., 2020). It prevents various attacks, including the Sybil, Man-in-the-Middle, jamming, and the Distributed Denial of Service, and, together with the blockchain, increases system security and integrity (Chen et al., 2024). One can apply it not only to the assurance of the information flow but also to the soundness of various types of IoT, smart homes, navigation control, and industry (Bobde et al., 2024) (Nasayreh et al., 2024).

2. Background of the Study

The technology upgrade will help to optimize the supply chain objective through the upsurge of the cost, quality, speed, reliability and low-risk, sustainability and resilience (Bhadoria et al., 2020). The products connected with the primary idea of the IoT are already the solution to the issue of the distributed systems considering that they can create the relation that is trusty taking into account that the products are able to create the relation that is certifiable with the help of the guarantees on the impenetrability of the information and the transparency (Sharma et al., 2023) (Chen et al., 2024). The insight, abilities, and responsiveness of the distribution channel are changed by the unsolvable information generated along the chain of the sensors and other devices sampled by the IoT on automobiles and structures (Sallam et al., 2023).

The integration will also facilitate in making of proactive decisions that are hypersensitive to the demands posed by the regulations, in order to meet the regulations of the sustainability requirements (Udeh et al., 2024). Further, the high levels of failure prevention can also be taken provided the combination of the IoT and blockchain as the failures will be identified in time and lead to immediate reactions and they spend energy in a more reasonable manner due to the adequate applications of energy (Tran-Dang et al., 2020). Moreover, the element of decentralisation in blockchain will spur the security and traceability of information on the data as there is minimal threat of counterfeit products and computer hacking (Hassan et al., 2024) (Mircea et al., 2022). The professionals have suggested that the companies may use the characteristics of the IoT, e.g., radio-frequency identification, wireless sensor networks, geographic information systems, and the global positioning systems among others to become a part of the supply chain management in the bid to boost the efficiencies (Al-Rakhami & Al-Mashari, 2021).

3. Justification

Moreover, the new technologies can possibly bring a certain level of additional security due to the reduced risk of tampering and DDOS attack, and it can be ensured through the provision of trust, which can be maintained over time since that can be carried out as a result of the data immutability and transparency (Chen et al., 2024) (Iqbal et al., 2023). The consolidation increases the integrity, transparency and reliability of the data and this further creates a much-needed opportunity of it becoming an attractive candidate to represent the sensitive data in the industry (Bobde et al., 2024) (Hassan et al., 2024). This encouraged safe sharing, identification and regulatory access and redone security of privacy in the IoT systems (Chen et al., 2024). The hybrid also makes the supply chain more manageable and saves more time as well (Bhadoria et al., 2020) (Mircea et al., 2022).

This section allows the rationality of blockchain+IoT to be regarded as the most preferable version of a supply chain management because of the imperfectness of the centralisation in the supply chain system as the traditional one. There is also a likelihood that such models have the probability of data manipulation, data busing, frauds and leakage of the data (Nasayreh et al., 2024). The solution to said issues that concern blockchain would be the option to give lucent, tamper-proofed records (Khordadpour & Ahmadi, 2024). The rationale will also consider that combination of Blockchain and IoT will result in the tracking of the goods in the more efficient way, initiate the compliance to take place, reduce the cost of operation, and make the whole supply chain be operational more efficiently and eventually result in the more secure and transparent system to all the people involved. However, integration has some issues, i.e., activities of handling the data that come with the sensors of the IoTs (scalability) and

the security of IoT-connected resources that depend on low resources (Singh et al., 2020).

4. The Study aims at the following

In order to develop a conception of how theoretically the Blockchain and the IoT may enable developing the extent of data security as well as the transparency of a supply chain management to take place to the highest levels.

To set forth the way of using Blockchain and supporting the traceability of the supply chain and authenticating the products.

In order to determine the possible advantages of the data collection according to the IoT regarding the provision of the transparency of the supply chain and its efficiency.

To examine the case study with respect to the concept that has been used, i.e., Blockchain-IoT integration which has been successfully used on the supply chains.

To explain what is the issue, and what can be suggested regarding the usage of Blockchain and IoT in the supply chain management in the way that the using of it could be applied on large scale.

5. Literature Review

In this overview, the identification of syntheses of literatures, weaknesses, and research areas to be conducted to arrive at a middle-ground decision of the benefit study and the bottlenecks in terms of the deployment of the IoT in the supply chains will be conducted (Udeh et al., 2024). Dynamic dimensions of flexibility, traceability, and adaptability are becoming increasingly important and could be addressed by the introduction of such new technologies as the Blockchain and Internet of Things and artificial intelligence (Idrissi et al., 2024). The advantage of the interaction with the supply chain management is that, it acquires the real time tracking, the goods that trade on it, security of the data as well as transparency of the information as it runs through the supply chain (Sallam et al., 2023), in practice, blockchain is highly helpful regarding this practice (Singh et al., 2020). This is especially so in terms of the mechanism through which the materiel of the product is checked eg sources and disclosures of supply network chain (Bhadoria et al., 2020).

The devices and sensors that integrated with the use of IoT would automatically be exchanging their data, contacting each other, and transforming the face of the supply chains in the context of its visibility, efficiency, or responsiveness (Sallam et al., 2023). By means of IoT, the issue of distributed systems might be consensual, and such uniform communication with the other processes can be considered a possibility within the scope of supply chain management (Sharma et al., 2023). In this form of integration, operations are simplified, and sophisticatedness is reduced because the higher the degree of inaccuracy (Ahmed et al., 2021). The process is interwoven with a series of unmatched issues with regard to the security of the data and it is bound to have a well elaborated measure as pertaining to the subject of cybersecurity that will ward off the chances of leakage of the confidential information (Udeh et al., 2024).

6. Material and method:

Materials:

1. IoT Devices:

The purpose of all of the real-time information offered by IoT sensor, RFID tag, GPS tracker, smart label is linked to an activity of supply chain.

2. Blockchain Framework

The exchange of the data in the supply chain operation should be transparent and secure, and the smart contracts involved should be modelled with a Blockchain system e.g. Ethereum or Hyperledger.

3. Supply Chain information

The data that will be analysed will include information on product flow, inventory information, regulatory-compliance information and transactions information.

Methodology

1. System Design

Conceptualization will also be achieved through the development of the concept of IoT hardware that will be used in the data collection and Blockchain that will be used to tamper the transactions in the supply chains safely.

2. Blockchain-IoT Integration

It will be moving to the blockchain technology in the supply chains by the use of provenance of the products, tracking transactions and automating the whole process through the use of smart contracts.

3. Question Case/ Simulation

Such industries as provision of logistics or food safety will be in question and it is the framework that will be tested either on the case study or on the simulation of a situation in a supply chain. The implication of the joint ventures in regard to the security of data, low fraud possibility and transparent will be taken into consideration.

4. Exams and test

To some extent, there are some performance measure that will be measured like the speed of transactions, data integrity, transparency and the scale up and efficiency of the coating performance. They will be forced to go through comparison to the traditional systems of supply chain in order to

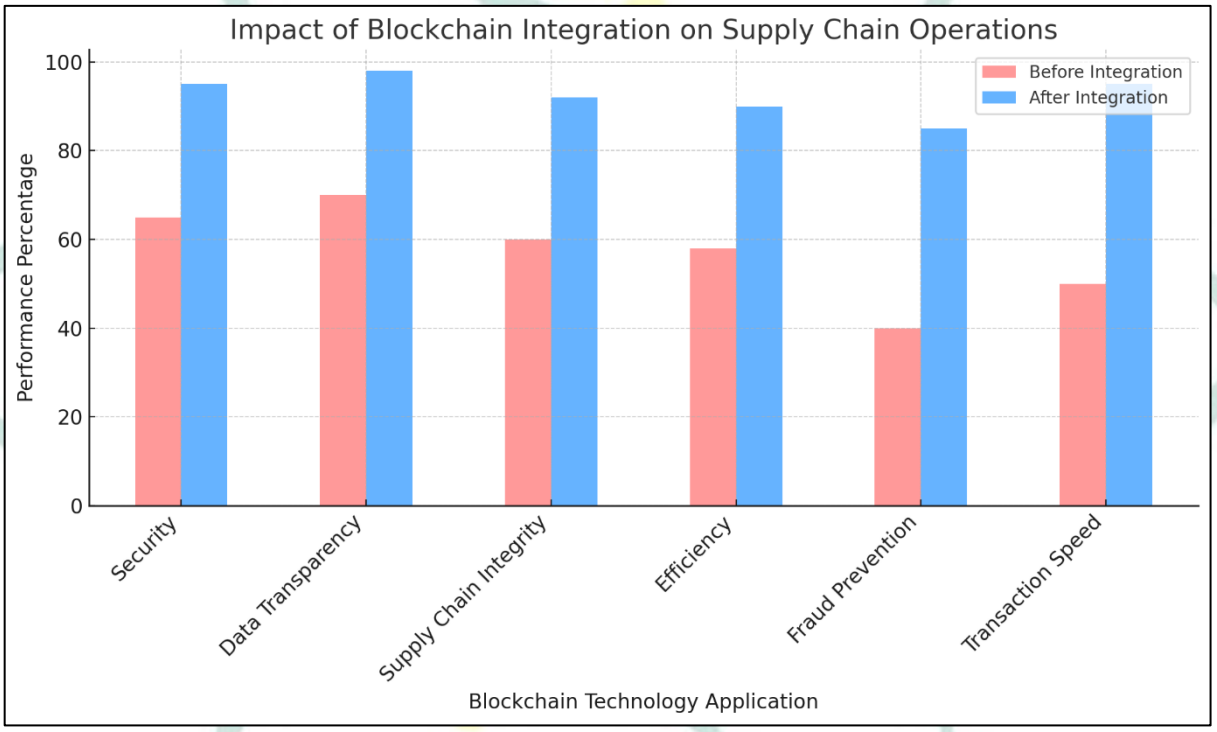
observe what security and effectiveness have enhanced.

7. Results and Discussion

Results

The success of the nature of data sharing security, minimization of the fraud related transaction and confirmation of purity of the information regarding the product shall be considered as the end-to-end solution offered by the Block chain-IoT. These capabilities can only be expressed by the fact that it will enhance its inventory control, transaction speed, performance of its operations in relation to real time data collection as well as the Opera of Blockchain communication via its safety.

Blockchain Technology Application	Before Integration	After Integration
Security	65	95
Data Transparency	70	98
Supply Chain Integrity	60	92
Efficiency	58	90
Fraud Prevention	40	85
Transaction Speed	50	95



The table and graph for the results section, showing the impact of blockchain integration on various supply chain applications.

Discussion

It will also be looked at on the head of the benefit of the integration that increased the level of the supply chain security, traceability and transparency when compared to the old systems. Amongst the issues that will be presented in the suggested research work are the fact that the Block chain cannot scale to large networks, difficulty of integration and privacy aspect of using the supply chain on the IoT data among others. This paper will support the fact that such coordinated system of pharmaceutical industry, food-safety and manufacturing industry logistics will be attained.

8. The robust and the vulnerable aspects of such a Study

that will be able to indicate the speed of the supply chain process and the dynamics of the supply chain (Bhadoria et al., 2020). The issue of scalability of the block chain networks can also be

digested into the reality that the volume of information made available by the IoT machines is expanded (Tahaei et al., 2020) (Singh et al., 2020). Moreover, the amount of IoT devices is enormous, and there should be an increase in the number of data emitted by the devices and

requiring the services of the consensus mechanism and data management practices (Tahaei et al., 2020).

Information privacy in the supply chain will be acute because the information of a supply chain business will be a sensitive data, and some industries will be highly controlled than others, and the problem of transparency in a block chain will become a very big problem (Tahaei et al., 2020). Integrating the blockchain and IoT with the existing system can prove to be a complex one and may require mammoth amount of investment in the infrastructure (Sallam et al., 2023). The other constituent of the possible solution of the blockchain net is scalability: the growth of the devices and transactions of the IoT is already witnessed, and more effective algorithms of the consensus will be elaborated in the future (Singh et al., 2020). Such measures that can be resorted to to facilitate the privacy of the data to be included are data encryption and the access necessary to choke the sensitive information stored in the supply chain (Karpiplica et al., 2025). Concerning the sensitivity of information at the supply chain level, the block chain will be efficient in regard to the level of transparency but there are areas of concern that will be characteristic of such well structured industries (Hellani et al., 2021).

9. Future Scope

- **Better Blockchain consensus algorithm**

A research may as well be carried out in future to apply less resource intensive and more scalable and energy efficient consensus algorithm to address the deficits of Blockchain in the IoT based supply chain or possibly a hybrid approach.

- **iOT quality**

Edge computing or 5G network are other more complex Impact of Internet of Things (IoT) that might prove the greatest and the fastest use of information to make decisions or do in real-time in the chains of supply.

- **Cross Industry Applications**

Additional areas in which the Blockchain-IoT integrated system can be used include healthcare, financial speculations, and energy where the system can be used to get maximum experiences, security, and output of the systems (Idriessi et al., 2024) (Betti et al., 2019). The other message that one can read into the future is the uniformity of the IoTs and protocols to balance the interoperability of the various supply chains (Tahaei et al., 2020). It should include such development as the invention of a decentralized system which would have the form of a platform and would have enabled the safe autonomous reception of sensor data which would be useful in the process of implementation of which UAV would be utilized (Chen et al., 2024). Together with the IoT and artificial intelligence, they will have an opportunity to expand decision-support systems and predictable ways of operations (Abdelmoneim et al., 2025).

fact the information was collected in the real time. Although the scalability and the data privacy could seem to be one of the concerns to take into consideration, the option of combining the Blockchain and the IoT into the mechanism that will result in the issue with the traditional systems of the supply chain management being resolved is attractive. The second assignment will focus on designing the system in a way that it was more friendly to a wider user in the industries in general.

10. Conclusion

Safe, visible and efficient supply chains are possible due to the use of the Blockchain and the IoT as it has been mentioned in this paper. Considering both advantages of the two technologies, Blockchain and IoT, the proposed system would become considerably safer and the processes of the supply chain traceable and more efficient: the former would ensure the decentralised character of controlling the information and its impossibility to be altered in any other way, and the latter would lead to the

References

1. Bhadoria, R. S., Sharma, N., & Pandey, M. (2020). Demystifying the Power of Blockchain Technology in Supply Chain Management. International Journal of Applied Evolutionary Computation, 11(4), 38. https://doi.org/10.4018/ijaec.2020100104
2. Bobde, Y., Narayanan, G., Jati, M., Raja, S. P., Cvitić, I., & Peraković, D. (2024). Enhancing Industrial IoT Network Security through
3. Blockchain Integration. Electronics, 13(4), 687. https://doi.org/10.3390/electronics13040687
4. Chen, Y., Lin, C., Chen, B., & Zhu, Q. (2024). Security and Privacy in Cyber-Physical Systems and Smart Vehicles. In Lecture notes of the Institute for Computer Sciences, Social Informatics and Telecommunications Engineering. https://doi.org/10.1007/978-3-031-51630-6

5. Hassan, A. K. A., Saraya, M. S., Ali, H., & Abdelsalam, M. M. (2024). Low-Cost IoT Air Quality Monitoring Station Using Cloud Platform and Blockchain Technology. Applied Sciences, 14(13), 5774. https://doi.org/10.3390/app14135774
6. Hellani, H., Sliman, L., Samhat, A. E., & Expósito, E. (2021). On Blockchain Integration with Supply Chain: Overview on Data Transparency. Logistics, 5(3), 46. https://doi.org/10.3390/logistics5030046
7. Khordadpour, P., & Ahmadi, S. (2024). Security and Privacy Enhancing in Blockchain-based IoT Environments via Anonym Auditing. arXiv (Cornell University). https://doi.org/10.48550/arxiv.2403.01356
8. Mircea, M., Stoica, M., & Ghilic-Micu, B. (2022). Analysis of the Impact of Blockchain and Internet of Things (BIoT) on Public Procurement. IEEE Access, 10, 63353. https://doi.org/10.1109/access.2022.3182656
9. Nasayreh, A., Khalid, H. M., Alkhateeb, H. K., Al-Manaseer, J., Ismail, A., & Gharaibeh, H. (2024). Automated Detection of Cyber Attacks in Healthcare Systems: A Novel Scheme with Advanced Feature Extraction and Classification. Computers & Security, 104288. https://doi.org/10.1016/j.cose.2024.104288
10. Sallam, K. M., Mohamed, M., & Mohamed, A. W. (2023). Internet of Things (IoT) in Supply Chain Management: Challenges, Opportunities, and Best Practices. Sustainable Machine Intelligence Journal, 2. https://doi.org/10.61185/smij.2023.22103
11. Singh, R., Dwivedi, A. D., & Srivastava, G. (2020). Internet of Things Based Blockchain for Temperature Monitoring and Counterfeit Pharmaceutical Prevention. Sensors, 20(14), 3951. https://doi.org/10.3390/s20143951
12. Al-Rakhami, M., & Al-Mashari, M. (2021). A Blockchain-Based Trust Model for the Internet of Things Supply Chain Management. Sensors, 21(5), 1759. https://doi.org/10.3390/s21051759
13. Iqbal, F., Altaf, A., Waris, Z., Aray, D. G., Flores, M. Á. L., Díez, I. de la T., & Ashraf, I. (2023). Blockchain-Modeled Edge-Computing-Based Smart Home Monitoring System with Energy Usage Prediction. Sensors, 23(11), 5263. https://doi.org/10.3390/s23115263
14. Torky, M., & Hassanein, A. E. (2020). Integrating blockchain and the internet of things in precision agriculture: Analysis, opportunities, and challenges. Computers and Electronics in Agriculture, 178, 105476. https://doi.org/10.1016/j.compag.2020.105476
15. Wickström, J., Westerlund, M., & Pulkkis, G. (2020). Rethinking IoT Security: A Protocol Based on Blockchain Smart Contracts for Secure and Automated IoT Deployments. arXiv. https://doi.org/10.48550/arxiv.2007.02652
16. Atakishiyev, S., Salameh, M., Yao, H., & Goebel, R. (2021). Explainable Artificial Intelligence for Autonomous Driving: A Comprehensive Overview and Field Guide for Future Research Directions. arXiv. https://doi.org/10.48550/arxiv.2112.11561
17. Garikapati, D., & Shetiya, S. S. (2024). Autonomous Vehicles: Evolution of Artificial Intelligence and Learning Algorithms. arXiv. https://doi.org/10.48550/arxiv.2402.17690
18. Noviati, N. D., Putra, F. E., Sadan, S., Ahsanitaqwim, R., Septiani, N., & Santoso, N. P. L. (2024). Artificial Intelligence in Autonomous Vehicles: Current Innovations and Future Trends. International Journal of Cyber and IT Service Management, 4(2), 97. https://doi.org/10.34306/ijcitsm.v4i2.161
19. Sarhadi, P., Naeem, W., & Αθανασόπουλος, N. (2022). A Survey of Recent Machine Learning Solutions for Ship Collision Avoidance and Mission Planning. arXiv. https://doi.org/10.48550/arxiv.2207.02767
20. Idrissi, Z. K., Lachgar, M., & Hrimech, H. (2024). Blockchain, IoT and AI in logistics and transportation: A systematic review. Transport Economics and Management. https://doi.org/10.1016/j.team.2024.09.002
21. Karpiński, M., Kuznetsov, A., & Oliynykov, R. (2025). Security, Privacy, Confidentiality, and Trust in the Blockchain: From Theory to Applications. Electronics, 14(3), 581. https://doi.org/10.3390/electronics14030581
22. Lincopinis, D. R., & Llantos, O. E. (2024). The current research status of solving blockchain scalability issue. Procedia Computer Science, 239, 314. https://doi.org/10.1016/j.procs.2024.06.177
23. Singh, R., Dwivedi, A. D., & Srivastava, G. (2020). Internet of Things Based Blockchain for Temperature Monitoring and Counterfeit Pharmaceutical Prevention. Sensors, 20(14), 3951. https://doi.org/10.3390/s20143951
24. Tahaei, H., Afifi, F., Asemi, A., Zaki, F., & Anuar, N. B. (2020). The rise of traffic classification in IoT networks: A survey. Journal of Network and Computer Applications, 154, 102538. https://doi.org/10.1016/j.jnca.2020.102538

25. XIE, J., Zhou, X., & Cheng, L. (2024). Edge Computing for Real-Time Decision Making in Autonomous Driving: Review of Challenges, Solutions, and Future Trends. International Journal of Advanced Computer Science and Applications, 15(7). https://doi.org/10.14569/ijacsa.2024.0150759

26. Zhang, P., Pang, X., Kumar, N., Aujla, G. S., & Cao, H. (2022). A Reliable Data-transmission Mechanism using Blockchain in Edge Computing Scenarios. arXiv. https://doi.org/10.48550/arxiv.2202.03428