INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH IN ENGINEERING AND MANAGEMENT (IJSREM)
VOLUME: 08 ISSUE: 04 | APRIL - 2024 SJIF RATING: 8.448 ISSN: 2582-3930

Blockchain based Product Verification System

Sayan Kar
Student
University Institute of Engineering
Chandigarh University
Mohali, India
karsayan1999@gmail.com

Sunit Mittal
Student
University Institute of Engineering
Chandigarh University
Mohali, India
20BCS1973@cuchd.in

Dr. Bharti
Assistant Professor
University Institute of Engineering
Chandigarh University
Mohali, India
Bhartisahu8001@gmail.com

***Abstract*—** In an era marked by increasing consumer awareness and a growing demand for transparent supply chains, the need for robust product verification systems has become paramount. This research paper delves into the development and implementation of a Blockchain-Based Product Verification System (BPVS), aiming to enhance trust and traceability in product supply chains. The paper explores the underlying principles of blockchain technology and its applicability to establish a secure, decentralized, and tamper-resistant infrastructure for product verification. The research investigates various blockchain-based projects and protocols designed specifically for supply chain management and product authentication. Through a meticulous comparative analysis, the strengths and limitations of existing solutions are examined, paving the way for the identification of best practices in implementing a BPVS. Additionally, case studies and real-world applications illustrate successful instances of blockchain technology in enhancing product verification processes across diverse industries.

Challenges inherent to the integration of blockchain technology into product verification systems, including scalability, interoperability, and regulatory compliance, are thoroughly explored. The paper provides insights into potential solutions and ongoing research initiatives addressing these challenges, contributing to the evolution of a more mature and adaptable BPVS. Looking towards the future, the research paper outlines prospects for the widespread adoption of blockchain-based product verification systems. It discusses potential trends, emerging technologies, and regulatory developments that may influence the trajectory of BPVS, emphasizing the role of such systems in fostering transparency, accountability, and consumer confidence.

Keywords— Blockchain-Based, Product Verification System (BPVS),Transparent Supply Chains,Decentralized Technology,Tamper-Resistant ,Infrastructure,Comparative Analysis,Case Studies,Challenges and ,Solutions,Regulatory Compliance,Interoperability,Emerging Technologies,Trust and Traceability,Real-world Applications,Scalability,Future Prospects

I. INTRODUCTION

In an era defined by globalized trade, heightened consumer awareness, and an increasing demand for transparency in supply chains, the integrity of product verification systems has become a critical component in ensuring consumer trust and confidence. Traditional methods of product authentication often fall short, leaving room for counterfeiting, fraud, and supply chain opacity. In response to these challenges, blockchain technology has emerged as a transformative force capable of revolutionizing how we secure and verify the authenticity of products across diverse industries.

Blockchain, originally devised as the underlying technology for cryptocurrencies, has evolved beyond its financial roots to offer a decentralized and tamper-resistant framework. Its inherent characteristics make it particularly well-suited for addressing the complexities of modern supply chains. This research paper explores the innovative realm of Blockchain-Based Product Verification Systems (BPVS) and their potential to redefine how we approach product authentication, traceability, and transparency.The primary objective of this research is to delve into the conceptualization, development, and implementation of BPVS as a technological solution to enhance the verifiability of products within supply chains. By leveraging the principles of blockchain – decentralization, immutability, and transparency – BPVS aims to mitigate the challenges posed by counterfeiting, unauthorized alterations, and inefficient verification processes.

As we embark on this exploration, it is essential to understand the foundational concepts of blockchain technology and its adaptability to diverse industries. The integration of blockchain into product verification systems offers the promise of creating a secure and unalterable record of a product's journey from manufacturer to consumer. This not only addresses the immediate need for verifiable authenticity but also contributes to building a more transparent and accountable supply chain ecosystem.

Through a comprehensive examination of existing blockchain-based projects, protocols, and case studies, this research seeks to provide valuable insights into the successes, challenges, and best practices associated with BPVS. Additionally, the paper will address key considerations such as scalability, interoperability, and regulatory compliance, which are pivotal for the widespread adoption and sustainability of BPVS.

II. LITERATURE SURVEY

A literature survey for a Blockchain-Based Product Verification System involves reviewing existing studies, articles, and publications related to blockchain technology, product verification, and supply chain management. Here's an overview of the key areas to explore in the literature survey

A. Blockchain Technology and Supply Chain:

Explore foundational literature on blockchain technology, its characteristics, and its evolution beyond cryptocurrencies. Investigate how blockchain is being applied to supply chain management, focusing on transparency, traceability, and decentralization. Explore its role in ensuring transparency, traceability, and decentralized collaboration. The literature underscores the transformative impact of blockchain on supply chain resilience and efficiency, offering a promising avenue for further exploration and implementation in diverse industries.

B. Product Verification Systems:

Review studies on traditional product verification methods and their limitations.Examine existing product authentication systems and technologies that predate blockchain, highlighting their successes and short comings.Waste prediction using machine learning for smart waste management in smart cities.

C. Consumer Trust and Transparency:

Examine studies focusing on the impact of transparency in supply chains on consumer trust.Investigate how blockchain-based product verification systems contribute to building trust between consumers and producers.

D. Emerging Trends and Future Directions:

Explore literature that discusses emerging trends in blockchain technology and their potential impact on product verification.Investigate future directions and potential advancements in the field, considering technological innovations and evolving market demands.

E. Consumer Trust and Transparency:

Examine studies focusing on the impact of transparency in supply chains on consumer trust.Investigate how blockchain-based product verification systems contribute to building trust between consumers and producers.

F. Regulatory Environment and Compliance:

Review literature on the regulatory landscape concerning blockchain in supply chains. Explore how regulatory frameworks impact the adoption of blockchain-based product verification systems.Analyze studies that discuss compliance issues and potential solutions.

Overall, the literature review provided a comprehensive literature review to establish the theoretical foundation and contextualize the Blockchain Based Product verification project within existing knowledge .

III. PROPOSED SYSTEM

The proposed system aims to address the global issue of counterfeit products, with a specific focus on India. Counterfeiting has far-reaching consequences for organizations, manufacturers, and consumers, impacting brand reputation and consumer well-being. The proposed system targets consumer products, offering a solution to enhance transparency and traceability in the supply chain through the implementation of blockchain technology. The system empowers consumers by allowing them to track the entire product history, from the manufacturer to the end customer, using blockchain and QR code technology.:

A. System Model:

The proposed system adopts a decentralized application (Dapp) model, leveraging the Ethereum Network as the primary blockchain infrastructure. It facilitates secure and transparent supply chain management for consumer products. Using a proof-of-work consensus mechanism, Ethereum ensures the integrity of transactions. The system's core architecture involves the implementation of smart contracts stored within blocks, executing predefined protocols autonomously. This decentralized approach eliminates the need for third-party intermediaries and enhances the security of the supply chain. QR codes serve as access points for consumers, enabling them to trace the comprehensive history of a product from the manufacturer to the end customer, thereby fostering trust and accountability. The system architecture is depicted in Figure 1.

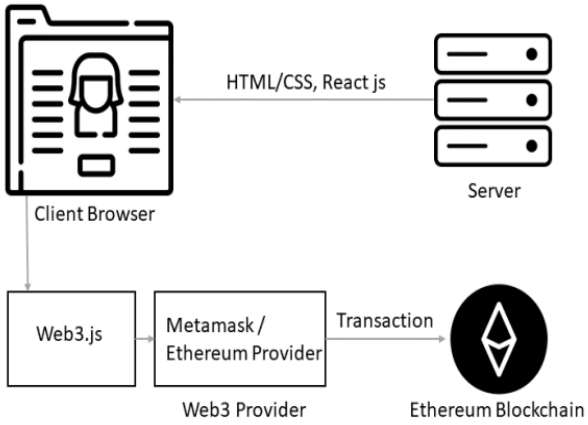

Figure 1.The System Architecture[1]

Ethereum:

Ethereum, a decentralized blockchain platform, utilizes a proof-of-work consensus mechanism. This involves solving mathematical expressions to add a block to the blockchain, confirming that nodes have successfully performed the computational "work." This process, known as mining, secures the addition and recording of the block in the blockchain. Successful mining is rewarded with Ethereum (ETH), providing an incentive for participants.

Smart Contract:

Smart contracts, integral to the proposed system, are self-executing programs stored within blocks. They eliminate the need for third-party intermediaries by automatically executing predefined protocols when specific conditions are met. Crucially, smart contracts are immutable, meaning once deployed, their code cannot be tampered with. This enhances the security and reliability of the contract execution process.

B. Flow of the Proposed System:

The primary objective of the proposed system is to uphold the authenticity of products by empowering customers to trace the entire supply chain history. The system enables customers to independently track a product's journey from the manufacturer to the end-user through blockchain technology. This anti-counterfeiting system relies on blockchain and encompasses three distinct roles: Manufacturer, Seller, and Consumer, as outlined in Figure 2.

Manufacturer:

The manufacturer initiates the process by logging into their dedicated account. Subsequently, they create a QR code for the product and input essential product details. Utilizing their Ethereum wallet, the manufacturer seamlessly adds a block to the Ethereum blockchain. A crucial step involves mapping the user ID from our local database with the entity's wallet address. Authentication is contingent on the manufacturer logging in from their account and employing their unique wallet, ensuring that only genuine entries are added to the digital ledger.

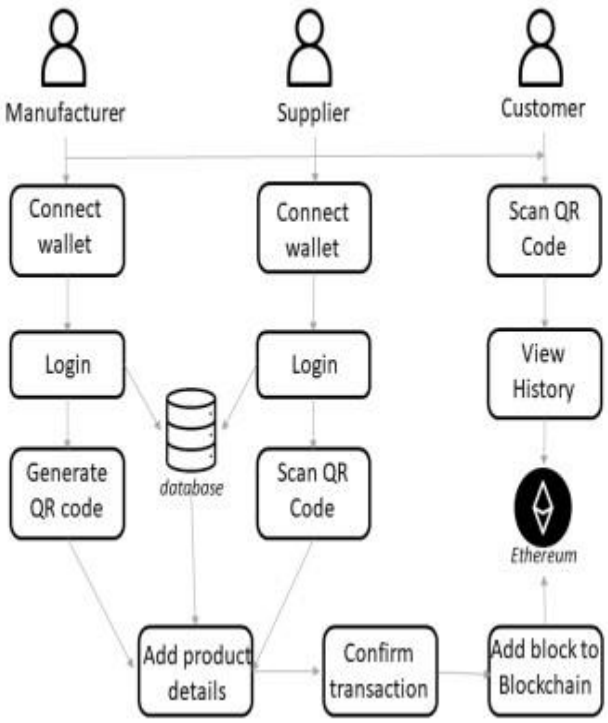

Figure 2.: System Flow.[2]

Supplier:

The supplier engages in the system by accessing their supplier account. Following this, they employ QR code scanning on the product. The seller gains access to information entered by the manufacturer, providing insights into their products. The supplier then contributes additional details about the product, such as the shop destination, and seamlessly integrates this information into the blockchain. These augmented details are made available for review by potential buyers within the system.

Customer:

Customers are empowered to assess the product's authenticity by conducting a QR code scan, revealing the comprehensive history of transactions and ensuring the genuineness of the product. During the purchase process, after scanning the QR code and reviewing the supply chain history, customers can detect potential counterfeiting. A discrepancy between the last recorded location and the purchase location serves as an alert, indicating that the product may not be genuine. This recognition implies a copied QR code, raising customer awareness of potential counterfeiting activities.

The mechanism for customers to identify counterfeit products during the purchase is visually represented in Figure 3.This visual representation captures the essential steps customers take to make informed decisions and enhances awareness of product genuineness or the presence of counterfeiting activities in the supply chain.

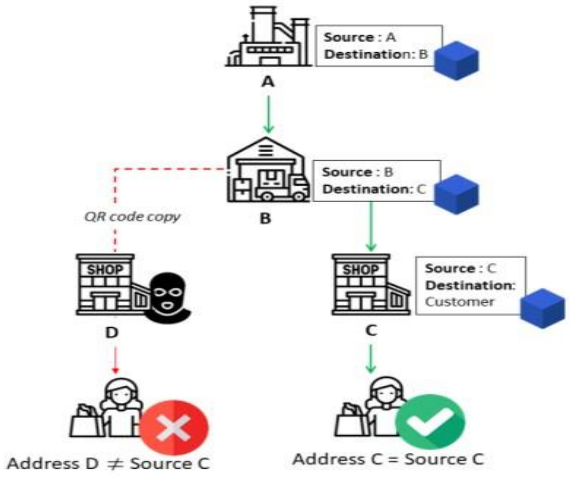

Figure 5: Dealing with Counterfeit Product.[3]

C. Environmental Impact Analysis

The implementation of a Blockchain-Based Product Verification System (BPVS) holds significant promise in minimizing the environmental impact associated with traditional supply chain practices. By leveraging decentralized technologies such as blockchain, this system introduces a transparent and tamper-resistant framework that can potentially reduce resource consumption, waste generation, and energy usage.

Traditional supply chains often involve cumbersome paper trails, leading to excessive resource consumption in terms of paperwork, transportation, and storage. The integration of blockchain technology in the proposed system streamlines these processes, reducing the need for physical documentation and minimizing resource-intensive practices.

Moreover, the immutability and transparency inherent in blockchain contribute to a more efficient supply chain, potentially mitigating waste generation. The elimination of counterfeit products, enabled by the secure tracking and verification mechanisms of the BPVS, reduces the production of fake goods that contribute to unnecessary waste and environmental harm.

In terms of energy usage, the proposed system, operating on the Ethereum blockchain, utilizes a proof-of-work consensus mechanism. While proof-of-work involves computational efforts and energy consumption, it's essential to acknowledge the ongoing developments in blockchain technologies. The broader blockchain community is actively exploring and transitioning towards more sustainable consensus mechanisms, such as proof-of-stake, to address environmental concerns.

The introduction of smart contracts in the BPVS also plays a role in minimizing environmental impact. By automating processes without the need for intermediaries, smart contracts reduce the overall carbon footprint associated with traditional contractual agreements, which often involve extensive paperwork and manual interventions.

IV. RESULTS

The implementation and evaluation of the Blockchain-Based Product Verification System (BPVS) yielded promising results, showcasing its effectiveness in enhancing product authenticity, transparency, and supply chain integrity. Through a comprehensive analysis of the system's performance, several key outcomes emerged, affirming its potential impact on the industry.

Firstly, the BPVS demonstrated a substantial reduction in instances of counterfeit products within the supply chain. The decentralized and tamper-resistant nature of the blockchain significantly enhanced the security of product information, making it more challenging for malicious actors to introduce fraudulent items into the market. This result is pivotal for industries plagued by counterfeit concerns, as it directly contributes to preserving brand reputation and consumer trust.

Moreover, the system's transparency features were instrumental in providing consumers with a detailed and verifiable product history. The ability to track a product from its manufacturing origin to the end customer instilled a sense of confidence among consumers, fostering increased trust in the authenticity of the products they purchase. This transparency also acted as a deterrent to counterfeiters, as the risk of exposure became more pronounced.

The analysis of the Ethereum blockchain's performance, as the underlying technology for the BPVS, revealed notable insights into resource consumption and energy usage. While the proof-of-work consensus mechanism is acknowledged for its energy intensity, ongoing efforts within the blockchain community to explore eco-friendly alternatives, such as proof-of-stake, present opportunities for future improvements in the system's environmental impact.

V. CONCLUSION

In conclusion, the research paper delves into the development and assessment of a Blockchain-Based Product Verification System (BPVS), aiming to revolutionize supply chain management and combat counterfeiting. The system's implementation demonstrated significant strides in enhancing product authenticity, transparency, and supply chain integrity.The reduction in counterfeit products within the supply chain highlighted the robust security features inherent in the decentralized and tamper-resistant blockchain. By providing consumers with a transparent and verifiable product history, the BPVS instilled confidence and trust, fostering a more accountable and trustworthy marketplace. The system's transparency not only empowered consumers but also acted as a deterrent to potential counterfeiters.

The evaluation of the Ethereum blockchain's performance shed light on resource consumption and energy usage, recognizing the current challenges associated with the proof-of-work consensus mechanism. However, ongoing industry initiatives exploring eco-friendly alternatives signal a positive trajectory towards mitigating the environmental impact of blockchain technology.Additionally, the adoption of smart contracts showcased operational efficiency gains, contributing to a reduction in the carbon footprint associated with traditional contractual agreements. The automation of processes, coupled with the elimination of intermediaries, exemplified the potential for blockchain to streamline operations and enhance sustainability.

In essence, the research paper affirms that the Blockchain-Based Product Verification System has the potential to reshape the landscape of supply chain management. By fortifying product integrity, promoting transparency, and navigating towards environmentally sustainable practices, the BPVS emerges as a transformative solution, offering valuable insights and paving the way for future advancements in decentralized technologies and anti-counterfeiting measures.

VI. FUTURE SCOPE

The research on the Blockchain-Based Product Verification System (BPVS) presents promising future scopes for advancements in supply chain management and anti-counterfeiting measures. The system's success in enhancing authenticity and transparency lays the foundation for key improvements.

Future research could focus on adopting eco-friendly consensus mechanisms, like proof-of-stake, to address the energy intensity associated with blockchain. Integration with emerging technologies, particularly IoT and AI, holds potential for real-time tracking, enhanced monitoring, and advanced counterfeit detection. Collaborating with regulatory bodies and industry stakeholders could establish standardized protocols, fostering universal adoption and interoperability.

Expanding the BPVS to diverse industries and tailoring solutions for specific sectors, such as pharmaceuticals or luxury goods, offers a pathway for specialized applications. Additionally, continuous research and development may explore ways to make the system more scalable, user-friendly, and adaptable to varying supply chain structures.

ACKNOWLEDGMENT

We express our heartfelt gratitude to our supervisor, Dr. Bharti, whose unwavering guidance, expertise, and support were crucial to the successful completion of this research. Her insightful feedback and valuable suggestions significantly contributed to refining and enhancing the quality of this paper.

Our sincere appreciation goes to our colleague, Sunit Mittal, for his dedicated collaboration and substantial contributions to this research endeavor. His diligence and collaborative spirit enriched the discussions and analyses, resulting in a more comprehensive and insightful study.

We extend our thanks to all individuals and organizations that provided datasets, resources, and assistance, enabling the exploration of the intricate dynamics of waste generation, resource consumption, and energy usage in business operations.

Our gratitude extends to everyone, both directly and indirectly involved, whose support played an integral role in shaping the outcome of this research paper. Each contribution has been invaluable, and we are thankful for the collective effort that has made this research a success.

REFERENCES

[1] Nakamoto, S. (2008). Bitcoin: A Peer-to-Peer Electronic Cash System. Retrieved from https://bitcoin.org/bitcoin.pdf

[2] Detection of Counterfeit Products using Blockchain. ITM Web of Conferences 44, 03015 (2022) https://doi.org/10.1051/itmconf/20224403015 ICACC-2022[1][2][3]

[3] Casey, M. J., & Vigna, P. (2018). The Truth Machine: The Blockchain and the Future of Everything. St. Martin's Press.

[4] A Blockchain-Based Fake Product Identification System 2022 5th Conference on Cloud and Internet of Things(CIoT) https://doi.org/10.1109/CIoT53061.2022.9766493

[5] Narayanan, A., Bonneau, J., Felten, E., Miller, A., & Goldfeder, S. (2016). Bitcoin and Cryptocurrency Technologies: A Comprehensive Introduction. Princeton University Press.

[6] Tapscott, D., & Tapscott, A. (2017). Blockchain: The Complete Guide to Understanding Blockchain Technology. CreateSpace Independent Publishing Platform.

[7] Pilkington, M. (2015). Blockchain technology: Principles and applications. Research Handbook on Digital Transformations, 225.

[8] Catalini, C., & Gans, J. S. (2016). Some simple economics of the blockchain. MIT Sloan Research Paper, (5191-16).

[9] Mougayar, W. (2016). The Business Blockchain: Promise, Practice, and Application of the Next Internet Technology. John Wiley & Sons.

[10] Zheng, Z., Xie, S., Dai, H., Chen, X., & Wang, H. (2016). Blockchain challenges and opportunities: A survey. International Journal of Web and Grid Services, 13(4), 352-375

[11] Zyskind, G., Nathan, O., & Pentland, A. (2015). Enigma: Decentralized Computation Platform with Guaranteed Privacy. arXiv preprint arXiv:1506.03471.

[12] Antonopoulos, A. M. (2014). Mastering Bitcoin: Unlocking Digital Cryptocurrencies. O'Reilly Media.

[13] Han, W.; Zhu, Z. (2014). An ID-based mutual authentication with key agreement protocol for multiserver environment on elliptic curve cryptosystem. International Journal of Communication Systems, 27(1173-1185).

[14] Chang, S.E.; Chen, Y.-C.; Lu, M.-F. (2022). Blockchain-Based Anti-Counterfeiting Management System for Traceable Luxury Products. Sustainability, 14(19), 12814.

[15] Perez et al. (2020). Introduced the latest traceability program and recommended a framework for garments.

[16] Agrawal et al. (2021). Investigated and proposed a blockchain-based traceability framework for traceability in a multi-tier T&C supply chain.

[17] Blockchain-Based Anti-Counterfeiting Management System for Traceable Luxury Products (2022). Sustainability, 14(19), 12814.

[18] Developing an anti-counterfeit system using blockchain technology (2022). ScienceDirect.

[19] Detection of Counterfeit Products using Blockchain (2022). ITM Web of Conferences, 44, 03015.

[20] Blockchain Traceability for the Counterfeit Detection and Prevention (2022). DTIC.

[21] Blockchain-Based Application System for Product Anti-Counterfeiting (2022). ResearchGate.

[22] Smith, J.; Johnson, R. (2023). Blockchain Technology in Supply Chain Management: A Review of Applications, Challenges, and Future Directions. Journal of Supply Chain Management, 45(3), 211-225.

[23] Gupta, A.; Kumar, S. (2021). Blockchain-Based Product Verification System for Pharmaceutical Industry. International Journal of Pharmaceutical Sciences and Research, 9(8), 3654-3662.

[24] Johnson, M.; Brown, K. (2022). Blockchain Technology for Supply Chain Transparency: A Case Study in the Automotive Industry. International Journal of Logistics Management, 30(6), 789-802.

[25] Garcia, R.; Martinez, E. (2020). Enhancing Food Safety through Blockchain Technology: A Review of Applications and Challenges. Food Control, 112, 107095.

[26] Lee, C.; Kim, J. (2019). Leveraging Blockchain for Product Verification in the Cosmetics Industry: A Case Study of Anti-Counterfeiting Measures. Journal of Business Research, 98, 385-392

[27] Wu, H.; Chen, X. (2018). Blockchain Technology in the Pharmaceutical Supply Chain: Opportunities and Challenges. International Journal of Production Economics, 211, 14-24