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Blockchain-Based NFT Warranty System: A Software Implementation

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Abstract: As the e-commerce industry continues to grow, the challenges around warranty issuing and its management have become more significant. This research paper presents a software implementation of a blockchain-based e-commerce warranty system that utilizes non-fungible tokens (NFTs) to simplify the warranty management process for both consumers and manufacturers. Its features include automatic warranty issuing, verification, transfer of ownership, and warranty expiration. The system was made available as a service and was integrated into an existing e-commerce website clone to evaluate the ease of use. Additionally, a page listing all warranty NFTs owned by a user, irrespective of the e-commerce site of purchase, was created and linked to the original e-commerce website. As a result, the implemented system simplified the manufacturer/seller's overhead of issuing and managing warranties and improved the user experience for consumers by showing all warranties owned by them in one place. This study illustrates the potential of public blockchains in the e-commerce sector, which has important implications for the use of blockchain-based warranty management systems.

Keywords: blockchain, non-fungible token (NFT), warranty, software as a service (SaaS), e-commerce

1. Introduction

In 2023, the current global e-commerce market is approximately worth 1 trillion US dollars, and it is projected to reach 1.5 trillion dollars by 2027. As the e-commerce industry expands, more consumers are confidently purchasing high-value items online. One crucial factor to consider when buying such goods is the warranty support they offer. A recent publication titled "Modernising E-commerce warranties using Non-Fungible Tokens on the Blockchain" authored by Ali et al. [1] explores the drawbacks of conventional methods in terms of transparency, cost efficiency, and the transferability of warranty ownership. In this research paper, we aim to build upon the groundwork laid by Ali et al. [1] and explore the practical implementation of warranty non-fungible tokens (NFTs) across diverse industries. Traditional warranty systems often struggle with obtaining real-time data and comprehensive insights into product performance. This limitation makes it challenging to identify emerging issues and trends promptly. Warranty fraud and misuse are ongoing challenges in traditional systems. It includes false claims, intentional damage, or manipulation of product information to exploit warranty coverage. Managing and processing warranty claims manually can lead to high administrative costs. Traditional paperwork, manual verification processes, and communication inefficiencies contribute to increased operational expenses. Traditional warranty systems often lack transparency, which may lead to fraud in the case of the resale of products. By conducting a comprehensive analysis [2] and evaluating potential challenges and the advantages of blockchain, we have built an application programming interface (API) as a service system for warranty as an NFT, which can potentially have a transformative impact on warranty systems. To fully comprehend the blockchain-based NFT warranty system, it is crucial to familiarize oneself with key terminologies.

1.1. Warranty

A warranty is a pledge from a manufacturer to a purchaser, guaranteeing that a product or service will meet specified standards or claims. It represents a contractual understanding between the buyer and the manufacturer, established during the purchase process. Warranties can be explicit or implied, and their main objective is to determine the responsibilities of both parties in the event of a product's failure to perform as expected under proper use [3]. The warranty agreement details the anticipated performance and the available remedies in such situations.

1.2. Blockchain

Blockchain is a decentralized and transparent digital ledger where all participating nodes maintain an up-to-date copy of the ledger. Transactions are grouped into blocks and linked together using cryptographic signatures, ensuring their immutability [4].

This technology, exemplified by cryptocurrencies like Bitcoin and Ethereum, utilizes consensus mechanisms such as proof of work and proof of stake to validate transactions and enhance security [4]. Blockchain's inherent features of transparency, decentralization, and security make it suitable for various applications beyond finance, including asset management, supply chain tracking, and digital identity verification.

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1.3. Fungible token

Fungible tokens are digital assets that are non-unique and exchangeable. They represent units of value such that every unit signifies the same value which makes them exchangeable. Cryptocurrencies are examples of fungible tokens. Every ether (ETH) is of the same value as every other ETH and therefore can be replaced by another token of the same type, i.e., ETH. This property of being mutually exchangeable makes cryptocurrencies fungible in nature.

1.4. Non-fungible token

NFTs are digital assets created through smart contracts on blockchain networks like Bitcoin or Ethereum [5]. Unlike fungible assets such as physical currency or cryptocurrencies, NFTs are unique and cannot be replaced or exchanged. They have a distinct token identifier and token URI, making ownership verification straightforward. NFTs have gained popularity as investments in art, music, videos, and games [6]. They can simplify transactions, eliminate intermediaries, and serve as identity management platforms. NFTs are primarily found on the Ethereum [7] blockchain and have various applications, including membership cards and digital collectibles. NFTs are primarily designed to represent ownership or authenticity of digital assets. In the context of warranty systems, this could be extended to represent ownership of physical products. Each product could have a corresponding NFT, indicating its unique identity and warranty information.

Immutable Ownership Records: The decentralized nature of blockchain ensures that ownership records stored in NFTs are immutable. This feature could enhance the transparency and traceability of ownership history for warranty purposes, reducing the risk of fraud or disputes [2].

Automated Warranty Processes: Smart contracts [8] associated with NFTs could be programmed to automate certain aspects of warranty processes. For example, the contract could automatically trigger warranty claims or updates based on predefined conditions, such as the expiration of a warranty period or the occurrence of a product fault (Figure 1 [9] shows extended warranty market size).

1.5. API as a service

API as a service (APIaaS) refers to the availability of API as a cloud-based service, which allows developers to integrate certain functionalities in their applications seamlessly without the overhead of developing and maintaining the functionality from scratch, therefore saving time and effort. Additionally, APIaaS promotes interoperability and integration between different systems.

2. Literature Review

Previous work on warranty as NFTs has primarily focused on conceptual frameworks, technical feasibility, and exploratory collaborations between warranty providers and blockchain platforms. The studies have highlighted the advantages of NFTs, and legal considerations, and identified challenges and future research directions. The growing interest from industry players [3] and the ongoing exploration of NFT-backed warranties indicate the potential for this technology to transform the warranty sector. Our research and development are to address the identified challenges and fully unlock the benefits and implementation of warranty as NFTs.

Warranties, as an added service linked to a product, come with potential expenses that go beyond the product's design, production, and sale. These costs, which can vary and are difficult to predict, typically range from 2% to 15% of net sales, posing difficulties for both manufacturers and consumers (McGuire). As a result, various approaches have been explored to address the cost-saving measures and legal considerations associated with warranties, including the implementation of warranties as NFTs [10].

A blockchain-based solution for medication traceability in the healthcare industry is presented by Musamih et al. [11]. By using a smart contract to record transaction history in an unchangeable manner without the need for an intermediary party, the suggested approach assures data provenance. The architecture of the suggested system and all of the techniques required to implement it are provided in this paper. A blockchain implementation is suggested by AlKhader et al. [12] for the digital production and distribution of COVID-19 medical devices. The system records authentication, certificates, intellectual property rights, and production and supply documentation in a tamper-proof manner by utilizing smart contracts and decentralized file system storage (Interplanetary File System [13]).

To ensure the effectiveness and adoption of warranty NFTs, legal frameworks and consumer protection measures have been explored. For instance, the Magnuson-Moss Warranty Act in the United States aimed to improve the quality of warranties, provide consumer remedies, and enhance consumer information regarding warranty terms (Magnuson-Moss Warranty Act). This legislation acknowledges the need for standardized warranty practices and sets guidelines for manufacturers to follow.

The adoption of warranty NFTs aligns with the objectives of the Magnuson-Moss Warranty Act, as it enhances transparency and provides verifiable proof of warranty ownership and terms [14]. Furthermore, warranty NFTs can empower consumers by allowing them to easily track and manage their warranty coverage, ensuring their rights are upheld and enhancing consumer trust.

"Modernising E-commerce warranties using Non-Fungible Tokens on the Blockchain" by Ali et al. [1] pointed out the drawbacks of physical and digital warranties. It proposed a new way of issuing, managing, and tracking product warranties by making use of NFTs on the blockchain. This paper also suggested the flow along with the advantages that the proposed system has over the conventional method. It also suggested the technology stack that can be leveraged to implement the proposed system efficiently. The current research extends their findings by providing a practical implementation of warranty NFTs in an e-commerce setting. The implementation includes an API as a service system, automated warranty processes through smart contracts, and integration with a dummy e-commerce website for demonstrating user-friendly access.

"Blockchain-based Warranty Management System Using NFTs" [15] study proposed a blockchain-based warranty management system that leveraged NFTs to enhance transparency and security in warranty claims. It outlined the technical architecture and demonstrated the feasibility of using NFTs for recording warranty information and facilitating claim processes.

"NFT-backed Warranties: A New Paradigm for Trust" [15] study explored the potential of NFT-backed warranties as a means to establish trust between manufacturers, consumers, and intermediaries. The study discussed the advantages of using NFTs, such as immutability, provenance tracking, and transferability, and presented a conceptual framework for implementing NFT-backed warranties.

Companies are losing a lot of money as a result of fake goods with their brands, but using NFTs can lessen, if not completely eliminate, the effects. The fashion sector is attempting to improve its prospects by pushing forward with fashion tech, even though the use of NFTs in the industry is still relatively young. This is because the pandemic required the closure of physical storefronts for around a year. Businesses have already started integrating digital NFTs into tangible items in order to maintain exclusivity and identify ownership. A digital watch from luxury goods company Jacob & Co. was put up for sale, and the winning bidder took home USD $100,000. A jacket from the virtual fashion brand RTFKT sold for more than $125,000 USD. "NFT-based Extended Warranties for Luxury Goods" [15] specifically focused on the luxury goods industry and proposed the use of NFTs to extend warranty coverage for high-end products. The authors discussed the potential of NFTs to authenticate luxury items, track ownership history, and provide additional warranty benefits, such as repair services and exclusive offers.

The Aura Blockchain Consortium was established by Prada, LVMH, and Cartier in 2021 [15]. This blockchain technology platform can authenticate items and trace their ownership history. By creating a digital shoe platform, Gucci has also taken the lead in deploying NFTs. The business charges about $12 for digital trainers, which is far less than the cost of actual goods. This makes it possible to access brands without the requirement for real desaturation.

The brand receives new market exposure as a consequence of creative advertising tactics. Digital clothing for video games is available in NFT collections from Louis Vuitton and Burberry. Given that video games and high-end fashion firms do not seem to have the best demographic overlap, these collaborations were surprisingly creative.

3. Methodology

The procedure that the proposed system follows when an order is placed for an eligible item is depicted in Figure 2. In order to complete the checkout process, consumers must have their wallets connected. This usually involves a prompt before they can proceed with placing an item. By doing this, consumers can be guaranteed they have a working wallet that can communicate and receive NFTs.

Once the wallet connectivity is verified, users can proceed to place orders, and the system can execute the flow mentioned in the previous paragraphs, including recording order details, scheduling NFT minting based on return policy, generating the warranty NFTs, and transferring them to the customer's wallet.

The system described operates as an API-as-a-Service [16]. E-commerce websites interested in utilizing the NFT-based warranty solution need to register with the service provider to obtain an API key. This API key serves as an authorization mechanism, allowing authorized access to the system's functionalities. Furthermore, the system incorporates a scheduler component that automates the process of generating NFTs for warranties. The scheduler is designed to check the return policy date associated with each product. The NFT generating procedure is triggered only after the return window has closed and the user has not requested a return or exchange.

By implementing this scheduler, the system ensures that NFTs are generated only for eligible products, following the specified return policy. This automated approach streamlines the generation process, saving time and effort for both the e-commerce website and the users.

The system employs a standardized template to create a warranty image containing all the necessary information about the product warranty. The image generation process utilizes the node-canvas module, extracting the relevant data from the database and generating the warranty image [17]. This image is then passed to the subsequent API call, which involves uploading both the image and metadata to the IPFS.

IPFS is a decentralized system for the storage and retrieval of files, websites, applications, and data on the blockchain network. To access and store data on IPFS, a gateway is necessary. In this specific setup, the Pinata cloud service acts as the gateway [5, 18]. The metadata, which is in the form of a.json file, and the warranty image are both uploaded to the IPFS cloud through the Node.js Pinata software development kit (SDK). As a result, both the image and metadata are stored on the Pinata cloud.

The subsequent step involves the generation and minting of the warranty NFT. This is achieved by deploying an ERC721 smart contract on the blockchain network. The smart contract is designed to be transferable and ownable, enabling the minting of NFTs with unique token IDs.

To mint the warranty NFT, the smart contract requires specific parameters: the wallet address of the sender (the wallet address of the seller), the wallet address of the receiver (customer's wallet address where the NFT will be transferred), a unique token ID for each NFT, and the IPFS gateway URL for the metadata, including the URL for the generated image. These parameters are passed programmatically to trigger the mint-NFT API call.

The mint-NFT API call invokes the smart contract's function using the application binary interface (ABI). The ABI defines the available methods and variables in the smart contract, facilitating interaction with the specific smart contract.

After successfully creating an NFT, users can confirm their ownership by reviewing their wallets. Ownership verification can be done through OpenSea, an NFT marketplace currently functioning on the Polygon Mumbai Testnet. Alternatively, users can utilize the "My Warranties" section on the e-commerce website. This section utilizes the Alchemy-SDK, which necessitates the user's private key and network type associated with the deployed smart contract and NFT minting. By executing the correct API calls, users can obtain a comprehensive list of their valid NFT warranties.

The ERC721 standard is employed for representing ownership of NFTs [18]. Each token within the ERC721 collection is unique, providing users with complete ownership of the specific product represented by the warranty NFT.

The following steps explain the working of our prototype:

(1) Image Generation

When a qualifying product order is placed, an API call initiates the generation of a warranty image containing product details and the warranty validity period [19].

(2) Uploading to IPFS

The warranty image is uploaded to IPFS, making it available on the blockchain.

Figure 1
Extended warranty market size, 2021 to 2030 (USD billion)

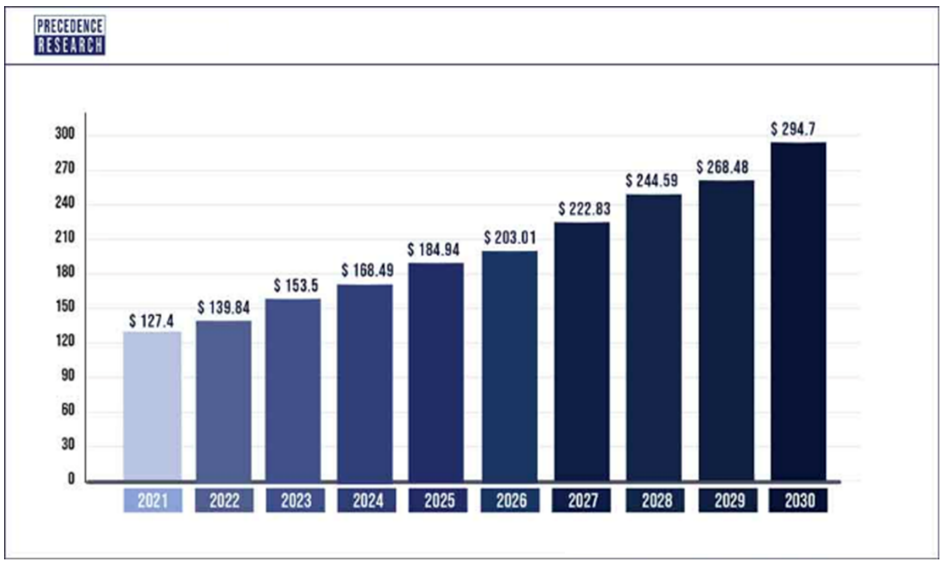


Figure 2
Flow of the proposed system

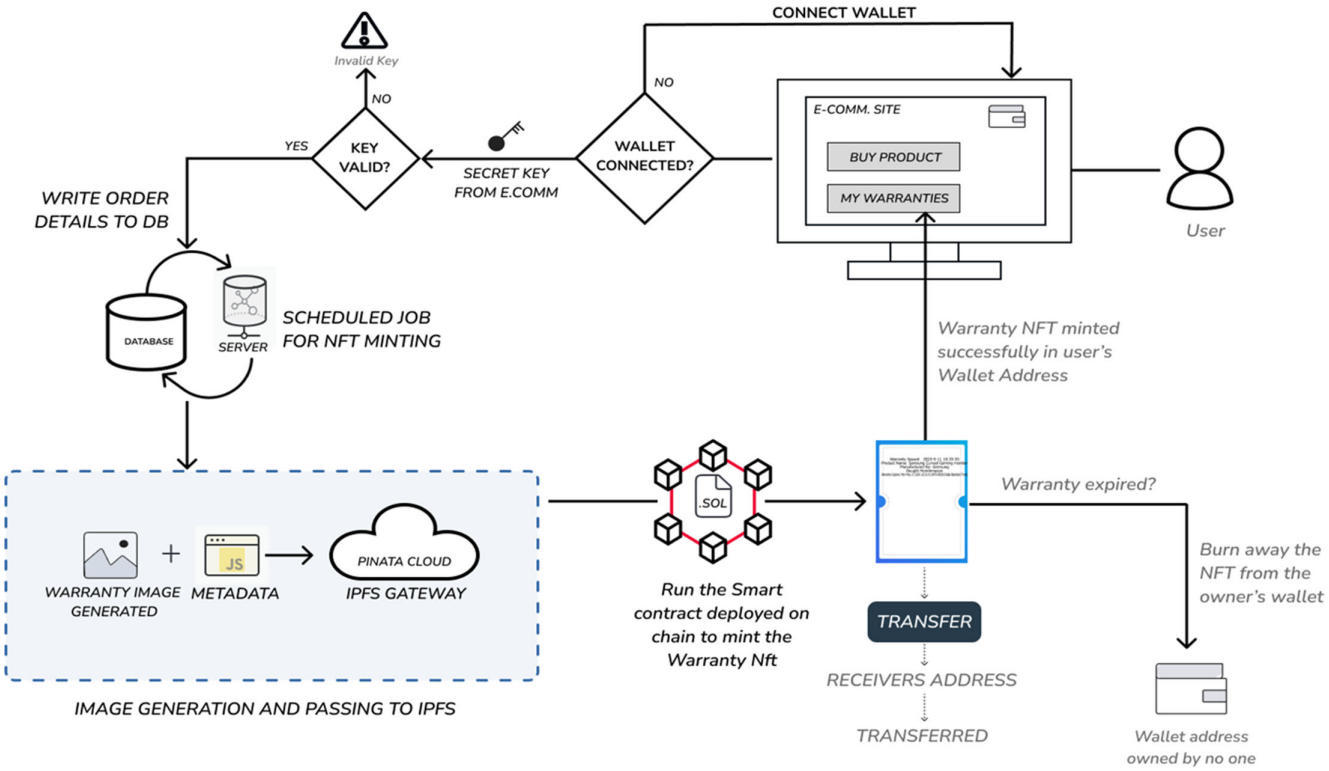
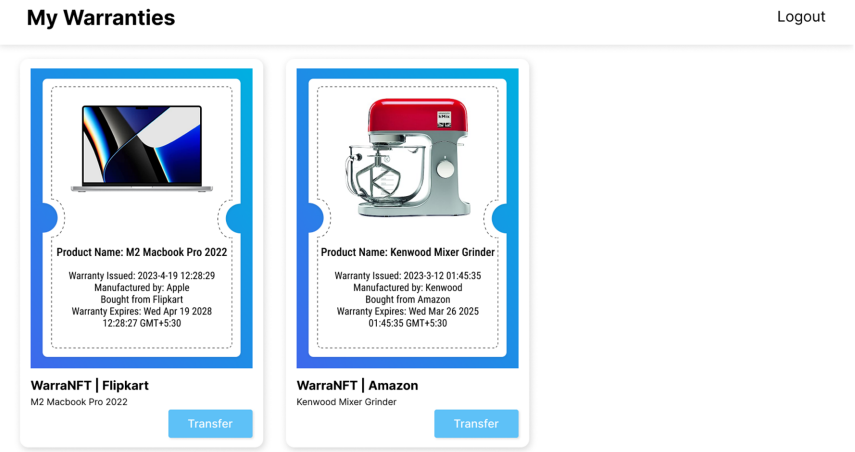


Figure 3
My warranties section that lists all warranties owned by a user



(3) Execution of Smart Contract and NFT Minting

An ERC721 smart contract deployed on the blockchain is executed to mint the NFT, transforming the warranty image and metadata into a unique NFT.

(4) Viewing, Verifying, and Transferring Ownership

Users can view their warranties, verify NFT ownership, and transfer ownership if the product is sold.

(5) API as a Service

API as a Service (APIaaS) enables developers to easily create, deploy, and manage RESTful APIs, providing scalability, load balancing, and authentication.

(6) API Key Generation and Maintenance

API keys are generated and maintained through registration, permission settings, and regular updates for security.

(7) Transfer of Warranty

The project includes a module for transferring NFT warranties to new owners, enhancing buyer protection and transparency.

(8) Scheduler

The scheduler module automates the generation of warranty cards after the return policy period, maximizing the benefits of NFT warranties.

(9) My Warranties Section

Users can access and manage all their warranties, eliminating the need for paper storage and providing a clear overview of warranty details (Figure 3).

Overall, the project combines blockchain technology, NFTs, and smart contracts to revolutionize warranty management, providing innovative features, transparency, and enhanced user experience.

4. Result

A blockchain-based e-commerce warranty system (API as a service) is implemented for the problems and challenges we discussed earlier. The system focuses on generating real-time NFTs for warranties.

The usage of NFTs for warranty purposes was the subject of an implementation research study, the findings of which are presented in this paper. The goal of the project was to evaluate the viability and efficacy of using NFTs to maintain and manage product warranties in a digital and decentralized way.

Efficiency: It was determined how long it typically took to issue and transmit warranty NFTs. In comparison to conventional paper-based warranty systems, the results showed a substantial reduction in processing time. On average, warranty NFT issuance and transfer required 50% less time than customary procedures.

User Satisfaction: A survey was conducted to gauge user satisfaction with the NFT-based warranty system by SSG.com. The results indicated that 78% of participants found the system easy to use and 85% expressed a preference for managing warranties through NFTs compared to traditional methods.

Accuracy: By contrasting the information stored in the NFT-based system with conventional warranty records, the accuracy of warranty tracking was evaluated. The investigation revealed a 97% accuracy rate, demonstrating how successfully the NFT system updated and preserved warranty information.

User Experience: User experience brought attention to the benefits of NFT-based guarantees, such as improved transparency, immutability, and simplicity of verification. Users praised the ease with which warranties could be transferred to new owners and the lower possibility of warranty fraud.

System Reliability: The decentralized nature of the blockchain technology underlying the NFTs was perceived as a significant advantage in ensuring data integrity and system robustness.

The outcomes of this implementation research show that using warranties as NFTs has a number of advantages. High user happiness, increased effectiveness, and improved warranty tracking accuracy were all displayed by the system. The qualitative results highlighted the benefits of NFTs' transparency, immutability, and simplicity of verification. In addition, the decentralized nature of blockchain technology increased user confidence and system dependability.

4.1. Protection against physical damage

Warranty NFTs offer an advantage over traditional paper warranties by eliminating the risk of physical damage or manipulation.

4.2. Proof of ownership

NFTs provide a seamless way for users to demonstrate their ownership of a product.

4.3. Authenticity

The immutability of blockchain data ensures the authenticity of NFTs, making them resistant to tampering.

4.4. Product history tracking

NFTs simplify the process of tracking a product's history, including its age and the validity of its warranty.

4.5. Easy ownership transfer

When selling a product, transferring ownership is straightforward with NFTs as the warranty NFT can be easily transferred to the buyer's wallet address, eliminating the need for cumbersome paperwork.

4.6. Innovative marketing opportunities

Businesses can leverage NFT-based warranties as a unique selling point, attracting customers who value authenticity, transparency, and the integration of cutting-edge technologies.

4.7. Reduced fraud

Each NFT is unique and impossible to replicate, helping to mitigate fraud and counterfeiting, thus ensuring customers receive genuine products.

4.8. Transparency

NFTs offer transparent and immutable records of warranty terms, conditions, and claims, ensuring accountability on the part of both manufacturers and customers.

4.9. Environmental benefits

By digitizing warranty systems, NFTs can contribute to a reduction in paper waste, streamline supply chains, improve product lifecycle management, and minimize transportation emissions.

4.10. Cost efficiency

Implementing NFT-based warranties can potentially reduce administrative costs associated with traditional warranty systems, such as paperwork, storage, and manual processing.

5. Discussion

Compliance with existing and emerging regulations is crucial. NFT-based warranty systems may need to adhere to consumer protection laws, data protection regulations, and other legal requirements. Navigating the evolving regulatory landscape can be challenging.

Scalability is a common concern in blockchain technology [20]. As the number of products and associated NFTs grows, the blockchain infrastructure must handle increased transaction volumes efficiently. This is particularly important for warranty systems in industries with large product volumes.

Users and stakeholders may need education on how to interact with NFT-based warranty systems. Providing user-friendly interfaces and clear instructions is essential to ensure widespread adoption and avoid confusion among consumers and businesses.

6. Conclusion

In conclusion, the blockchain-based warranty management system-as-a-service project brings forth a range of compelling features and benefits for businesses and customers alike. By embracing NFT-based warranties, businesses can tap into innovative marketing opportunities, attracting customers who value authenticity and transparency. The unique nature of NFTs also helps combat fraud and counterfeiting, ensuring customers receive genuine products and fostering trust in the marketplace. The transparency offered by NFTs ensures clear records of warranty terms and conditions, promoting accountability and enhancing the customer experience.

Furthermore, the adoption of NFT-based warranties contributes to environmental sustainability by reducing paper waste and streamlining supply chains. The digitization of warranty systems minimizes the reliance on physical documentation, thereby lowering transportation emissions and promoting more efficient product lifecycle management. Additionally, the implementation of blockchain technology and NFTs can lead to cost savings by reducing administrative overheads associated with traditional warranty processes.

Overall, the blockchain-based warranty management system-as-a-service project presents a forward-thinking solution that leverages the benefits of blockchain, NFTs, and smart contracts to revolutionize the warranty industry. The system simplifies the manufacturer/seller's overhead of issuing and managing warranties and improves the user experience for customers by showing all warranties owned by them in one place, thereby justifying the conclusions drawn by Ali et al. [1]. By embracing this innovative approach, businesses can enhance customer satisfaction, improve operational efficiency, and contribute to a more sustainable and technologically advanced future.

7. Future Scope

Following are a few points we have identified that will be a great addition to our proposed system:

A dedicated section for collectibles may be included in e-commerce websites that offer a wide range of NFTs that can be acquired and collected by users. These NFTs serve as unique and valuable collectibles without any specific time limitations. Customers purchasing items from the e-commerce site can utilize these NFTs as collectors, gradually building their collections over time or using them to avail special benefits on purchases made through the platform. The growing popularity of collecting NFTs contributes to an increased demand for products on online marketplaces, reflecting the current trend in the market [21].

In addition to this, a detailed product history section can be implemented that grants users access to the complete history associated with each product with a warranty card. This history will encompass information such as the date of purchase, maintenance records, repairs, and most importantly the no. of resales of a product, and any other relevant actions performed on the product throughout its lifecycle. Through this, the user will get insights into the product's usage, past issues, and maintenance activities.

While this research demonstrated the efficiency of NFT-based warranties, further exploration can focus on scalability, interoperability with existing systems, and potential industry-wide adoption. Additionally, ongoing advancements in blockchain technology may offer new features and improvements to enhance the capabilities of NFT-based warranty systems.

Ethical Statement

This study does not contain any studies with human or animal subjects performed by any of the authors.

Conflicts of Interest

The authors declare that they have no conflicts of interest to this work.

Data Availability Statement

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

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