

Original Article

Blockchain Based Intelligent System for Non-Fungible Token: A Novel Approach

Vijaya U. Pinjarkar¹, Vaishali V. Sarbhukan², Jyoti S. More³

¹Department of Information Technology, K.J. Somaiya Institute of Technology, Sion, Mumbai, Maharashtra, India.

²Department of Information Technology, Fr. Conceicao Rodrigues Institute of Technology, Vashi Maharashtra, India

³Department of Computer Engineering, Fr. Conceicao Rodrigues Institute of Technology, Vashi, Maharashtra, India

¹Corresponding Author : vkhirodkar@somaiya.edu

Received: 18 March 2024

Revised: 17 May 2024

Accepted: 01 July 2024

Published: 26 July 2024

Abstract - Non-Fungible Tokens (NFTs) have become increasingly popular as a means of trading digital assets on NFT marketplaces. However, most NFT marketplaces are centralized and owned by a single entity, leading to issues such as high fees, lack of transparency, and censorship. Furthermore, there are many challenges faced while implementing and deploying an actual system to a test or production network. The purpose of this research paper is to analyse the current state of NFT marketplaces and implement a decentralized NFT marketplace using blockchain technology, along with evaluating the challenges faced in the process. The study uses a mixed-methods approach, including surveying several existing systems and previous implementations to identify the challenges and opportunities faced by creators and buyers in the current NFT marketplace ecosystem. Additionally, development and implementation use technologies such as React for the front end, Truffle and Ganache for the back end, and “Metamask” as the wallet to develop the proposed decentralized NFT marketplace. The outcome of this research will contribute to the development of a more open and decentralized economy for digital creators and buyers for a greater level of transparency in transactions.

Keywords - Blockchain, Non-fungible tokens, Decentralized apps (dapps), React, Ganache, Truffle, Metamask.

1. Introduction

The rise of blockchain technology has paved the way for the creation of unique digital chattels called “Non-Fungible Tokens” (NFTs). These tokens are used to represent anything from digital art and music to in-game items and collectibles, providing a new medium for creators and collectors to trade and showcase their work[1]. The NFT market has grown exponentially in recent years, with prominent auction houses and galleries hosting NFT sales. The distinctiveness of NFTs—unique digital assets registered on blockchains—sets them different from other cryptocurrencies. These non-transferable tokens, which represent tangible or digital goods and are exchanged on certain platforms, have sparked continuous conversations concerning the environmental effects of blockchain technology. NFTs are often used to represent digital assets like artwork, music, videos, games, collectibles, and more, with more and more marketplace and similar projects becoming quite prevalent. NFT marketplaces have abundant applications across a range of industries. One of the most significant applications is in the art world [2], [3], where NFTs enable artists to monetize their digital art in a way that was not previously possible. NFT marketplaces allow artists to sell their unique digital creations as one-of-a-kind assets, providing them with a new revenue stream and a way

to establish their ownership and authorship of the art. NFT marketplaces also have applications in gaming, where they can be used to embody in-game items and assets [4]. This enables gamers to own and trade their in-game items in a way that is secure and transparent. In addition, NFT marketplaces can be used to represent physical assets, such as real estate or luxury goods. This enables the ownership of physical assets to be tracked and traded on a blockchain-based platform, providing greater transparency and security. Overall, NFT marketplaces have the potential to disrupt a wide range of industries by providing a new way to monetize and trade digital and physical assets securely and transparently. In this research paper, we propose the development of a decentralized NFT marketplace using blockchain technology. Our platform will use a range of technologies, including JavaScript (JS), React, Truffle, Ganache, OpenZeppelin ERC721 NFT standard, ExpressJS, and Metamask, to ensure a secure and user-friendly experience for all stakeholders. The proposed platform will have several key features. Firstly, it will be decentralized, meaning that there will be no single entity controlling the marketplace. Transactions will be executed using smart contracts, ensuring that buyers and sellers are protected from fraud and that all transactions are transparent. Secondly, the platform will use a secure wallet integration,



ensuring that users' funds and NFTs are stored safely. Thirdly, the platform will have a user-friendly interface that makes it easy for creators to list their NFTs and for buyers to purchase them. To develop our platform, we will use an approach that combines qualitative and quantitative research. We have thoroughly analyzed existing systems and research in the domain of NFTs to understand the experiences of users and enthusiasts of current NFT marketplaces and identify the challenges they face. We have also evaluated several difficulties faced throughout the process of developing the system mentioned above. The quantitative data on user preferences and behavior is the data used to inform the design of our platform and ensure that it meets the needs of its users.

The outcome of this research will contribute to the development of a more open and decentralized economy for creators and collectors in the NFT marketplace. By using blockchain technology and a range of cutting-edge technologies, we aim to create a platform that is secure, transparent, and user-friendly. This platform will provide creators with a means of selling their digital assets without intermediaries, reducing fees and increasing transparency. At the same time, buyers will be able to purchase NFTs with greater security and confidence, knowing that they are purchasing unique and verified digital assets. In this paper, we have added background information, summarized briefs of existing implementations, and our proposed system specifics, as well as the areas with the potential to be further considered and developed in the future.

2. Related Work

2.1. Literature Review

Through analyzing numerous sources and thoroughly evaluating their particulars, their core ideas expressed are as follows: The research paper written by [5], "Value and Application of Blockchain Technology in Business: A systematic review by use cases", makes it extremely easier for us to understand the real-time application of companies by deploying smart contracts using blockchain. Its central idea is around the usefulness of decentralization of blockchain and its ability for transparency, trustworthiness and asset management. The paper fails to highlight the impact of the effect that cryptocurrency has had on the world economy.

In [6], the authors exhibited a system of similar technology by the name of "A Blockchain based Education Digital Assets Management System", which presents an architecture for an "educational digital asset management system based on blockchain 3.0 technology". It converts various data created by students during and after the classroom learning process, as well as courseware and experience data created by teachers during instruction, into "educational digital assets" and performs the necessary blockchain confirmation and storage. Ethereum is the backbone by which an NFT marketplace is made as the distributed ledger system in the blockchain. [7] "NFT Marketplace based on Ethereum Blockchain" displays how the current market NFT solutions are working and what can be done to provide better solutions. The existing systems, while being good in nature, have scope for improvement which is where our project works alongside it to fill those gaps in their systems and develop an even better one. We outline current research challenges that are highlighted before reaching mass market production.

Talks about issues such as Data redundancy, Transaction autonomy and Avoiding duplicity. If these problems were to occur, it would become really difficult to get back the data that was lost. In [8] "A comprehensive study on Ethereum blockchain based digital marketplace using NFT Smart Contract Infrastructure", the author compares the performance of the "Ethereum blockchain based digital marketplace" against the "centralized digital marketplace".

According to the feature analysis, the suggested system is a decentralized and distributed ledger that addresses several important security concerns. Also, NFT-based smart contracts establish ownership of creative content. Digital market listing fee-based payment schemes reduce market share risk for marketplace owners. [9] "Analysis of the NFT's Potential Impact in an E-commerce Platform: A Systematic Review" is a systematic review paper that analyses the potential impact of NFTs in an e-commerce platform. The survey conducted as part of the study revealed that most respondents believed NFTs could be beneficial for e-commerce, citing reasons such as authentication, trust, customer value, commodity, security, and proof of ownership.

2.2. Study of Existing System

Table 1. Study of existing system

Sr No.	Ref.	Title	Objective of Research Work	Practical Implications	Summarized Results and Analysis	Boundaries
A. Existing System for Digital Asset						
1	[6]	A Blockchain-based educational digital assets management system.	Proposing blockchain-driven educational asset management: secure storage, credibility assurance, personalized	Blockchain in education promises innovation but requires coordination, standardized	Analysis suggests artificial blockchains for scenario analysis, tackling	Challenges in applying blockchain to educational asset management include unresolved defects, scalability issues, smart

			learning, and tailored curricular strategies for effective teaching assessments.	protocols, training, and research investments, balancing potential with practical challenges.	network attacks and offline nodes, with a proposed third-party evaluation unit ensuring data integrity.	contract vulnerabilities, and integration complexities. Future research areas include enhancing performance and integrating with AI.
2	[1]	Non-fungible token(NFT): a token of digital assets on the blockchain	The main goal is to assess NFT application processes, technologies, and challenges, suggesting future research directions.	The paper explores NFT applications in AI content, asset integration, community autonomy, and Metaverse economics.	NFTs, with their distinctiveness and verification capabilities, are essential for asset applications leveraging blockchain technology.	The research highlights challenges like network security risks and industry development uncertainties in NFTs, including legal concerns.
3	[10]	Decentralized smart city of things: A blockchain tokenization-enabled architecture for digitization and authentication of assets in smart cities.	Proposing DSCoT, a decentralized smart city using blockchain NFTs for asset authentication and robust security.	DSCoT employs blockchain NFTs for user and IoT asset authentication, ensuring uniqueness and digitization, bolstered by smart contracts.	DSCoT proposes blockchain NFTs for user and IoT asset authentication, enhanced by smart contracts, ensuring security and efficiency.	Papers omit DSCoT limitations, focusing on functionality, security, and efficiency. Challenges include scalability, energy use, regulation, governance, and interoperability.
4	[11]	Real Estate Tokenisation via Non-Fungible Tokens	Research develops a crypto NFT for real estate data, addressing availability and veracity issues, leveraging tokenization, encryption, and decentralized trading.	Research suggests private tokens and blockchain for real estate tokenization, eschewing ERC standards, with hybrid proof of work/stake consensus.	Research proposes real estate NFT for data reliability, registering static and dynamic information on a private blockchain with hybrid consensus.	The paper lacks scalability analysis for handling transaction volume, comprehensive security evaluation, comparison with existing token standards, and regulatory considerations.
5	[12]	Unveiling the Innovative Empowerment of Non-Fungible Token for Creative Students: A Conceptual Framework	Explore NFTs for students in digital art, creating a framework to showcase and monetize creative work.	The study explores NFTs reshaping creative value and proposes educational integration for market readiness, emphasizing democratization and empowerment.	NFTs offer creative students recognition and financial gains through verifiable ownership scarcity but pose environmental and legal challenges.	The paper recognizes limitations: specific art forms, markets, and the dynamic nature of evolving NFT technology.
B. Existing System for Digital Art						
6	[2]	Non-fungible token and future of art.	The objective of the research work is to explore the impact of non-fungible tokens on the art world and asset ownership.	NFTs revolutionize art by empowering artists with direct monetization, ownership, and royalties, fostering a democratic market with enhanced authenticity and protection.	Blockchain-based NFTs reshape art sales, empowering artists, collectors, and authenticity.	NFTs encounter environmental concerns due to blockchain's energy usage, copyright risks from digital content, market volatility, regulatory ambiguity, and standardization needs.
7	[13]	An end-to-end blockchain-based non-fungible token platform for buying	Research explores blockchain and NFTs for digital art trading, aiming to develop a	NFTs empower artists with recognition, financial opportunities,	Sources discuss blockchain and NFTs' potential for artists, emphasizing	Though not explicitly stated, blockchain-based NFT platforms may face scalability,

		and selling digital arts.	platform fostering artist recognition and financial support.	ownership proof, global market access, and creative exploration.	reputation, financial support, ownership, market access, and creative freedom.	environmental, regulatory, market volatility, and adoption challenges.
8	[3]	Environmentally smart contracts for artists using non-fungible tokens.	Research aims: Actionable steps for eco-friendly blockchain/NFT practices, enabling artists to sell art responsibly.	ESC implementation makes NFT trades environmentally positive, discouraging proof-of-work transfers and aligning artist practices with sustainability.	ESCs guarantee eco-friendly NFT trades, dissuading harmful practices and enabling artists' guilt-free participation in the digital art market.	Proposed solutions lack full resolution; mainchaining and sidechaining fail to reconcile NFT benefits with environmental concerns.
9	[14]	Storytelling for Non-Fungible Token via Blockchain Technology: A Case Study of Layer Randomly Model for Digital Art Profile Picture (PPF).	1) To understand the role of storytelling in NFTs and digital art PFPs within the blockchain technology domain. 2) To develop a Layer Randomly model specifically for digitalart PFPs. 3) To create unique Digital Art PFPs using the developed model.	Learn from successful PFPs like CryptoPunks, emphasizing community, play-to-earn, storytelling, and random layering for digital art.	The model divides PFP creation into layers randomly, storytelling set, and collection, emphasizing diversity for NFT success.	While not explicitly outlined, potential limitations include diversity challenges in PFPs, scalability concerns, and subjective storytelling.
C. Existing System in E-commerce						
10	[15]	Modernising E-commerce warranties using Non-Fungible tokens on the blockchain	The research aims to revolutionize e-commerce warranties by introducing blockchain-based Non-Fungible Tokens (NFTs) for enhanced efficiency.	NFTs modernize e-commerce warranties, streamlining processes, ensuring security, and preventing fraud with blockchain transparency.	The paper proposes leveraging blockchain and NFTs to modernize e-commerce warranties, ensuring security, transparency, and ownership transfer.	The paper does not cover limitations, but challenges include adoption, technical complexity, scalability, regulation, and user acceptance.
D. Existing System in Healthcare Systems						
11	[16]	Non-fungible Tokens (NFTs) as a means for blockchain network integration in healthcare	Addressing health data challenges in fragmented blockchain networks using NFTs for secure, private information exchange in healthcare.	Private healthcare network utilizes Hyperledger Fabric, deploying NFT-based smart contracts for universal patient data access.	NFT data visibility challenges are addressed by encrypting medical information prioritizing transparency, confidentiality, and patient privacy.	Blockchain transparency, crucial for trust, poses challenges in protecting medical data. Solutions include robust encryption and authorization.
E. Existing System in Management Systems						
12	[17]	Event Management Evolution through Non-Fungible Tokens	Research explores NFTs' revolutionary role in sports event management, combating ticket speculation, and boosting fan engagement.	NFTs revolutionize sports event management, ensuring secure tickets, preventing scalping, and enhancing fan experiences for sustainability.	NFT integration in event management boosts ticket authenticity, reduces fraud, deepens fan engagement, and opens innovative avenues.	Promising NFT prospects in sports event management face challenges: limited understanding, scalability issues, and environmental concerns.

2.3. Scope of Improvement in Existing Systems

2.3.1. Lack of Comprehensive Analysis

- Overemphasis on blockchain benefits without addressing potential drawbacks.
- Neglect of crucial considerations like government approval and training requirements.

2.3.2. Need for Automation and Diversification of NFT Business Models

- Asset tracking model relies heavily on manual entries, lacking consideration for automation.
- Insufficient exploration of NFT business models beyond art, hindering their potential as secondary income sources.

2.3.3. Oversights in Security and Cryptocurrency Adoption

- Neglect of database tampering risks, especially concerning smart contracts in NFT marketplaces.
- Inadequate discussion of challenges associated with cryptocurrency adoption as the primary form of currency.

3. Proposed System Approach

The proposed solution is “Blockchain Based Intelligent System for Non-Fungible Token: A Novel Approach”. As shown in Figure 1, it is a platform that enables creators to sell their unique digital assets to buyers in a decentralized manner. The working of an NFT marketplace involves several key steps. Firstly, the creator lists their digital asset on the platform, providing a description of the asset, its history, and any associated files or metadata. The asset is then tokenized using a smart contract, which creates a unique NFT that represents the asset. This NFT is then made available for purchase by buyers on the platform.

The overall architecture of the system is shown in the figure 1. The transaction between the buyer and seller is executed using a smart contract, which ensures that the transaction is secure and transparent. The buyer sends the agreed-upon amount of cryptocurrency to the smartcontract and, in return, receives the NFT. The smart contract then sends the cryptocurrency to the seller minus any transaction fees.To ensure the security and transparency of the platform, a range of technologies are used.

The platform is built using a combination of front-end and back-end technologies, such as JavaScript (JS), React, Truffle, Ganache, OpenZeppelin ERC721 NFT standard, and ExpressJS. These technologies are used to build a user-friendly interface that enables creators to list their digital assets and buyers to purchase them.The platform also integrates with a secure wallet solution, such as Metamask, which enables users to store their cryptocurrency and NFTs securely. This ensures that users' funds and digital assets are protected from theft or fraud. In summary, NFT marketplaces enable creators to selltheir unique digital assets to buyers in a decentralized manner, using smart contracts to ensure secure and transparent transactions. The platform is built using a range of technologies to provide a user-friendly and secure experience for all stakeholders.

3.1. Features of the Proposed System

3.1.1. Fundamentals

The dApp provides the necessary functionality to securely connect to the wallet, such as MetaMask, and get the appropriate account information.

3.1.2. Interface Elements

The dApp also provides all the relevant interface elements to mint and purchase NFTs.

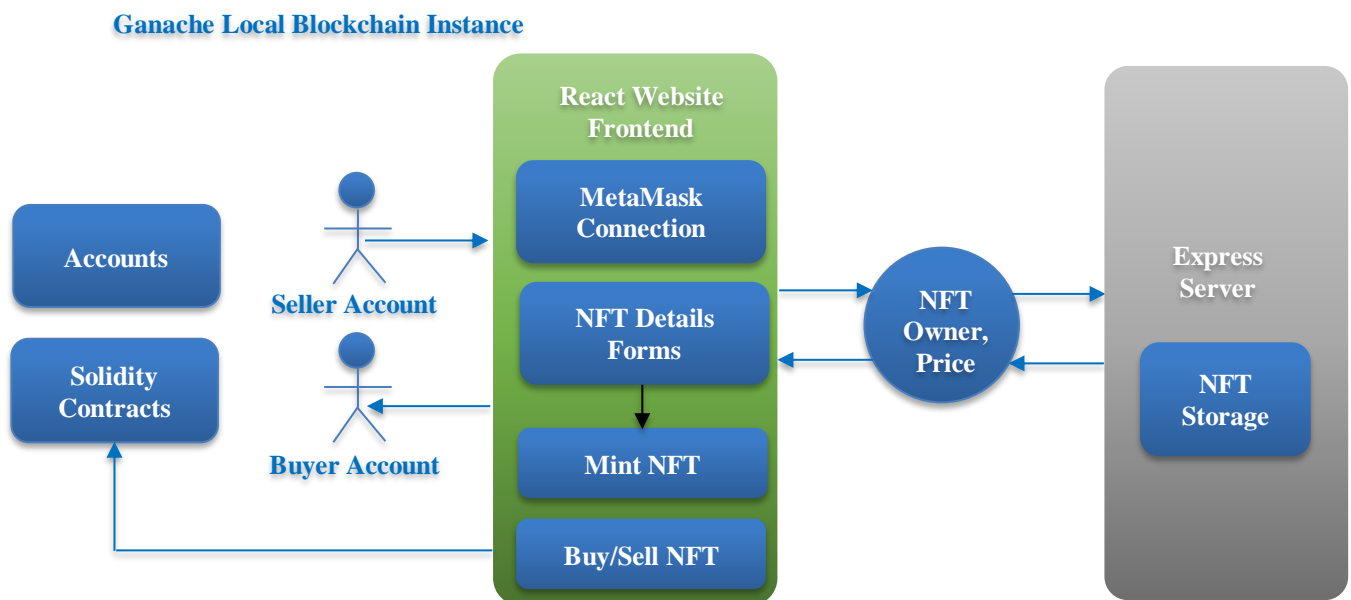


Fig. 1 Proposed system architecture

3.1.3. Front End

The front end created with React is further styled with Material UI and provides an affable interface for interacting with the contracts.

3.1.4. Minting NFTs

The users can select the option to mint their desired NFTs and they become registered on the marketplace.

3.1.5. Put for Sale

The users can put the NFT up for sale to be potentially bought by other users and specify the price for the purchase.

3.1.6. Buying NFTs

The users can purchase the NFTs which are listed on the marketplace.

3.1.7. NFT Tracking

NFTs can be minted using the application, and for it all the details can be provided by the user. When the details are provided, the user's account information is attached to the NFT metadata to denote the ownership of the NFT.

3.1.8. Conducting Transactions

The application connects securely to the wallet, facilitates the transactions between the buyers and sellers of the NFTs and takes care of all the related functions, such as transferring ownership and deducting the gas fees.

3.1.9. Security

Since its nature of connecting to the wallet and using the details securely along with preventing access to unwanted links on the app, the system is an overall secure system.

3.1.10. Transparency

All aspects of the system are open, from the smart contracts to even the JavaScript code used.

3.1.11. Compatibility

We are using Truffle and Ganache, which makes the system interoperable with Ethereum, one of the most widely used networks.

4. Implementation Detail

4.1. Solidity Smart Contracts

The ERC721 specification defines a set of functions that a smart contract must implement in order to create NFTs that can be traded, bought, and sold on the Ethereum network. These functions include minting a new token, transferring ownership of a token, and checking the owner of a token.

4.2. Truffle and Ganache

Truffle and Ganache are tools that can be used to set up a local blockchain instance for testing and development of decentralized applications (dApps) on the Ethereum network. They are the tools used in our solution to serve as the

blockchain instance of Ethereum since deploying to test networks, or even the mainnets can be quite a challenging task, frequently requiring monetization at each step.

4.3. React and Redux

React is a popular JavaScript toolkit for creating user interfaces, and Redux is a state management library that works with React to manage application data and state. React and Redux can be combined to create the front end of a decentralized application (dApp).

4.4. Express

Express.js is a popular web application framework for Node.js that has been used to build the backend of the decentralized application. In the context of an NFT marketplace, Express.js can be used to provide storage and management of NFTs by running a local server which stores the NFT details. The front end fetches all the NFTs from this server and interacts with it to manage their status.

4.5. Front End

A React project is created, and the various components of the web application and its user interface are developed. Redux is integrated with this to provide state management and streamline the development.

The styling of the application is done with the help of Material UI Components, providing beautiful designs of interactive web app components such as inputs in forms and menus, etc. Redux is a state management framework that provides a centralized store for maintaining an application's state, allowing for better tracking and administration of state changes.

4.6. Back End

The Ganache instance running in the background. Integrating a local Express.js server can help to manage the storage and information related to NFTs in a decentralized application. Express.js is a popular Node.js web framework that can be used to create RESTful APIs and handle HTTP requests. Here, it has been used to create a local server store of the NFT details and provides functions for its retrieval in the decentralized application.

5. Results and Discussion

In the result and Discussion section, let us see the step-by-step implementation of the proposed system. The implementation is done using a development tool. There are various development tools, and the proposed system is implemented in the Ganache development tool. Figure 2 shows the Ganache instance running in the background, a total of ten accounts holding 1000ETH.

When deployed the contract, the balance is deducted from the first account out of ten accounts, as shown in Figure 3. Figures 2 and 3 are the background processes, connected

6. Observation

1. An observation of the proposed system on the NFT marketplace is that the success of the project heavily relies on building a strong community of creators and buyers. Without a blossoming community, the marketplace may struggle to gain traction and generate sales.
2. Another observation is that the proposed system should consider the environmental impact of NFT minting and trading. As the demand for NFTs continues to grow, so does the concern about the carbon footprint of blockchain technology. To address this, the project could explore alternative blockchain solutions that are more energy-efficient or implement carbon offsetting programs to mitigate its environmental impact.

7. Conclusion and Future Scope

NFT marketplaces have the potential to revolutionize the way we view and trade digital and physical assets. By leveraging the power of blockchain technology, NFTs enable creators to monetize their unique digital creations in a way that was not previously possible while providing buyers with a secure and transparent way to own and trade these assets.

The combination of technologies such as JS, React, Truffle, Ganache, OpenZeppelin ERC721 NFT standard, ExpressJS, and Metamask has enabled the creation of NFT marketplaces that provide a secure and user-friendly way to trade digital assets. These technologies have been used to build platforms that enable creators to list their digital assets and buyers to purchase them in a decentralized and transparent manner.

Highlighting some of the potential areas with room for improvement in the application:

1. Integrating IPFS: The system can be improved in terms of its functioning by integrating decentralized storage, such as IPFS, for storing and retrieval of the NFTs.
2. Integrate more modern and widely used technologies such as hardhat.js and consider deployment on test networks like Goerli or Polygon.
3. Improve overall experience: Lower gas fees improve aspects like error handling and performance.

References

- [1] Jingyi Yang et al., "Non-Fungible Tokens (NFTs): Tokens of Digital Assets on the Blockchain," *CECCT '23: Proceedings of the 2023 International Conference on Electronics, Computers and Communication Technology*, Guilin China, pp. 175-182, 2024. [[CrossRef](#)] [[Google Scholar](#)] [[Publisher Link](#)]
- [2] Logan Kugler, "Non-Fungible Tokens and the Future of Art," *Communications of the ACM*, vol. 64, no. 9, pp. 19-20, 2021. [[CrossRef](#)] [[Google Scholar](#)] [[Publisher Link](#)]
- [3] Dan Weijers, and H. Joseph Turton, "Environmentally Smart Contracts for Artists Using Non-Fungible Tokens," *2021 IEEE International Symposium on Technology and Society*, Waterloo, ON, Canada, pp. 1-4, 2021. [[CrossRef](#)] [[Google Scholar](#)] [[Publisher Link](#)]
- [4] Yann-Jy Yang, and Jing-Lun Wang, "Non-Fungible Token (NFT) Games: A Literature Review," *2023 International Conference On Cyber Management And Engineering*, Bangkok, Thailand, pp. 251-254, 2023. [[CrossRef](#)] [[Google Scholar](#)] [[Publisher Link](#)]
- [5] Oscar Lage, María Saiz-Santos, and José Manuel Zarzuelo, "The Value and Applications of Blockchain Technology in Business: A Systematic Review of Real Use Cases," *Blockchain and Applications: 3rd International Congress*, pp. 149-160, 2021. [[CrossRef](#)] [[Google Scholar](#)] [[Publisher Link](#)]
- [6] Junqing Li et al., "A Blockchain-Based Educational Digital Assets Management System," *IFAC-PapersOnLine*, vol. 53, no. 5, pp. 47-52, 2020. [[CrossRef](#)] [[Google Scholar](#)] [[Publisher Link](#)]
- [7] Yogiraj Gutte et al., "NFT Marketplace Based on Ethereum Blockchain," *International Journal of Advanced Research in Science, Communication and Technology*, vol. 2, no. 3, pp. 179-186, 2022. [[CrossRef](#)] [[Google Scholar](#)] [[Publisher Link](#)]
- [8] Md. Momenul Haque et al., "A Comprehensive Study on Ethereum Blockchain-Based Digital Marketplace Using NFT Smart Contract Infrastructure," *2022 25th International Conference on Computer and Information Technology*, Cox's Bazar, Bangladesh, pp. 348-353, 2022. [[CrossRef](#)] [[Google Scholar](#)] [[Publisher Link](#)]
- [9] Eric B Blancaflor, and Kevin Aladin, "Analysis of the NFT's Potential Impact in an E-Commerce Platform: A Systematic Review," *ICCCM '22: Proceedings of the 10th International Conference on Computer and Communications Management*, Okayama Japan, pp. 239-245, 2022. [[CrossRef](#)] [[Google Scholar](#)] [[Publisher Link](#)]
- [10] Usman Khalil et al., "Decentralized Smart City of Things: A Blockchain Tokenization-Enabled Architecture for Digitization and Authentication of Assets in Smart Cities," *CCIOT '22: Proceedings of the 2022 7th International Conference on Cloud Computing and Internet of Things*, Okinawa Japan, pp. 38-47, 2022. [[CrossRef](#)] [[Google Scholar](#)] [[Publisher Link](#)]
- [11] Will Serrano, "Real Estate Tokenisation via Non Fungible Tokens," *ICBCT '22: Proceedings of the 2022 4th International Conference on Blockchain Technology*, Shanghai China, pp. 81-87, 2022. [[CrossRef](#)] [[Google Scholar](#)] [[Publisher Link](#)]
- [12] Nora Edrina Sahharil, Muhammad Fairus Kamaruzaman, and Hafizah Binti Rosli, "Unveiling the Innovative Empowerment of Non-Fungible Token for Creative Students: A Conceptual Framework," *2023 IEEE 12th International Conference on Engineering Education*

- (ICEED), Shah Alam, Malaysia, pp. 64-68, 2023. [[CrossRef](#)] [[Google Scholar](#)] [[Publisher Link](#)]
- [13] Dhruv Ajay Patill et al., "An End to End Blockchain Based Non-Fungible Token Platform for Buying and Selling Digital Arts," *2023 7th International Conference on Trends in Electronics and Informatics*, Tirunelveli, India, pp. 660-664, 2023. [[CrossRef](#)] [[Google Scholar](#)] [[Publisher Link](#)]
- [14] Wannaporn Chujitarom, and Chaiporn Panichrutiwong, "Storytelling for Non-Fungible Token via Blockchain Technology A Case Study of Layer Randomly model for Digital Art Profile Picture (PFP)," *2023 International Conference on Information Management*, Oxford, United Kingdom, pp. 88-91, 2023. [[CrossRef](#)] [[Google Scholar](#)] [[Publisher Link](#)]
- [15] Aaliya Ali et al., "Modernising E-commerce Warranties Using Non-Fungible Tokens on the Blockchain," *2022 OPJU International Technology Conference on Emerging Technologies for Sustainable Development*, Raigarh, Chhattisgarh, India, pp. 1-6, 2023. [[CrossRef](#)] [[Google Scholar](#)] [[Publisher Link](#)]
- [16] Ghassan Al-Sumaidae, Rami Alkhudary, and Zeljko Zilic, "Non-Fungible Tokens (NFTs) as a Means for Blockchain Networks Integration in Healthcare," *2023 5th Conference on Blockchain Research & Applications for Innovative Networks and Services*, Paris, France, pp. 1-2, 2023. [[CrossRef](#)] [[Google Scholar](#)] [[Publisher Link](#)]
- [17] Davide Carmelo Calderone, "Event Management Evolution Through Non-Fungible Tokens," *2023 IEEE International Workshop on Sport, Technology and Research*, Cavalese - Trento, Italy, pp. 85-89, 2023. [[CrossRef](#)] [[Google Scholar](#)] [[Publisher Link](#)]