International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 09 Issue: 05 | May – 2025 SJIF Rating: 8.586 ISSN: 2582-3930

Decentralized Non-Fungible Token (NFT) Marketplace Using Blockchain

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Abstract - Before blockchain technology became common, ways to check who owned digital assets and how to protect them were easy to alter. This caused big losses. Blockchain is a new development that will greatly affect how we trade data plus money in a connected society - it is still rather new, and academic studies are scarce, but this situation changes fast.

For this review, we first collected mostly peer reviewed sources. We also gathered helpful articles from many channels. The articles we chose show three important parts. They show the main subjects people discuss about blockchain technology. They show the principal groups of these subjects. They show how blockchain will develop also how it will affect society and technology.

***Key Words*:** Blockchain, NFTs, Ethereum, Tokenization, Digital Assets.

1.INTRODUCTION

Digital assets that represent tangible or digital creative works or intellectual property, such as music, digital art, games, GIFs, video clips, and more, are known as NFTs, or "non-fungible tokens." In NFT, "non-fungible" refers to the fact that each token is a distinct entity that represents a single, particular object and cannot be exchanged for another. These tokens are made up of digital data in the form of media (like music, videos, or pictures), and their worth is frequently determined in terms of cryptocurrency. Although NFTs are mostly a component of the Ethereum blockchain, they are not the same as Ethereum coins, which are fungible and convertible into other assets.

Technological progress and the NFT market expansion have led to growing security problems which focus on verifying authenticity. The non-fungibility characteristic of NFTs provides extensive protection against counterfeit threats because they are unique beyond substitution. An NFT includes the owner's cryptographic identity which enables straightforward ownership tracking along with authentication capabilities. Such identification helps consumers avoid buying fraudulent products like imitation tickets and artwork. Buyers can authenticate their ownership and follow the item's origin to guarantee legitimate transactions. NFTs opened a new market door for artists as well as businesses which found it challenging to build their online presence because there was no way to verify exclusive digital ownership.

NFTs really started to catch the public's eye when CryptoPunks launched back in October 2017. But it was the jaw-dropping sale of digital artist Mike Winkelmann, better known as Beeple, that truly catapulted them into the spotlight—he sold a piece of his artwork for nearly $70 million! This monumental sale turned heads and sparked a surge of interest in NFTs, leading to a boom in both artists and collectors jumping on board. What was once a niche interest within blockchain circles has blossomed into a vibrant market, racking up around $1.2 billion in sales by July 2021. In this paper, we're excited to introduce our project, ArtCart, a dynamic NFT art marketplace tailored for digital art and other digital assets. ArtCart is designed to empower creators to showcase and sell their work while giving buyers the option to resell items through cryptocurrency transactions.

This paper dives into some key topics, including:

- The remarkable rise in NFT adoption since it first came onto the scene.
- The significant hurdles that NFT applications face in today's tech and legal environments.
- The wide-ranging uses of NFTs across different industries.

The research paper is organized in a clear way: Section 1 kicks things off with an overview of NFTs, diving into the technologies behind their creation, their history, and where the market stands today. Then, Section 2 takes a closer look at the different ways NFTs are being used across various fields. In Section 3, we tackle the challenges that come with implementing NFTs. Finally, Section 4 wraps things up by highlighting the main findings and suggesting directions for future research.

2. Non-Fungible Tokens (NFT) – A Primer

This section gives a brief overview about the technologies being used around the concept of NFTs and the growth of NFT marketplaces.

A. Blockchain

So, what exactly is a blockchain? A blockchain is essentially a distributed digital ledger of transactions [2] that spans an entire network of computers. It works without

a central authority, which is cool! Bitcoin was the pioneer in using blockchain technology; it was introduced back in 2008 and went live in 2009 [3]. Since then, the idea of a distributed ledger has really taken off, especially in the financial world, where it has become a go-to solution. This popularity largely stems from the difficulty in pinpointing who owns an asset [4] at any given time.

Blockchain is all about verifying and authenticating ownership through a clever setup of data packages known as "blocks." These blocks are cryptographically linked together, creating a continuous chain—hence the term blockchain. Every time a new block is added, it boosts the integrity of the digital ledger. Now, Distributed Ledger Technology (DLT) refers to decentralized databases that are managed by multiple participants, and blockchain is just one specific type of DLT. In these blockchain networks, transactions are recorded with a unique cryptographic signature called a hash, which helps maintain data integrity. Since each hash value is one-of-a-kind, any change made to a block will instantly alter the hash, making it easy to spot any fraud.

Thanks to its decentralized nature, blockchain allows for transactions that are both transparent and resistant to tampering. But its uses go far beyond just cryptocurrency and finance. Researchers and developers are diving into its possibilities in areas like public and social services, security and privacy, smart contracts, and even the Internet of Things (IoT).

B. Ethereum

Ethereum is a software platform run by the community that allows people to create and launch decentralized applications (dApps) using blockchain technology. It comes with a built-in Turing-complete programming language and an abstract layer, which gives users the ability to set ownership rules, define transaction formats, and establish methods for state transitions. This is achieved through smart contracts, which are self-executing agreements based on cryptographic rules that only trigger when predefined conditions are met [6].

Ethereum is the backbone of its own cryptocurrency, Ether (ETH), which powers the various distributed applications on the platform. You can use Ether for a bunch of things: transferring funds, running dApps, creating smart contracts, generating tokens, and making peer-to-peer payments. This versatility is what has earned Ethereum the nickname "programmable currency" [7]. Ethereum is made up of two main types of accounts: Externally Owned Accounts (EOAs), which are managed through private keys, and Contract Accounts, which operate based on smart contract code. Each Ethereum account has four essential components: a nonce that keeps track of the number of transactions, an ether balance, a contract code hash (if it applies), and a storage root that points to the data stored on the Ethereum blockchain.

C. NFT Marketplace (Buying and selling NFTs)

Minting an NFT is all about turning digital art into a piece of the Ethereum blockchain. Think of NFTs as tokens that get “minted” after they are created, much like how metal coins are produced and put into circulation. Once an NFT is minted, that digital art can be bought, sold, and tracked digitally throughout its entire journey.

The NFT market really took off in the latter half of 2020, especially when an NFT artwork fetched a staggering $69 million. By the end of that year, total NFT sales hit $2.5 billion, and just the first half of 2021 saw sales soar past $10.7 billion, showcasing the industry's explosive growth. Right now, the average trading volume in the NFT market sits around $4 billion over a 24-hour period, which is quite a contrast to the entire cryptocurrency market's $341 billion.

There are plenty of online marketplaces where you can buy and sell NFTs, but some stand out more than others, as you can see in Table I. It is important to note that not every marketplace caters to the same kinds of collectibles or digital art, so the availability of NFTs really hinges on the platform you choose. While many of these marketplaces boast a wide variety of NFTs, each one has its own distinct structure and set of rules.

Table-1: Top NFT Marketplaces

Market	Traders	Volumes
OpenSea	46,067	$73.45m
Axie Infinity	40,429	$19.44m
CryptoPunks	12	$2.45m
AtomicMarket	7103	$1.03m
PancakeSwap	1342	$783.74k

In 2021, there was a remarkable surge in interest surrounding NFTs. Marketplaces like Nifty Gateway and OpenSea reported their highest trading volumes during the first quarter of the year.

3. NFT Applications

This section dives into the different ways NFTs are being used and how they are changing the landscape of digital assets for the future.

A. Digital Art

Digital art is all about creative content that lives in the digital realm—think music, films, paintings, images, and so much more. Just like traditional art, it can be sold by artists and snapped up by collectors and enthusiasts alike. But here is the catch: digital art is at risk of being counterfeited and stolen. That is where NFTs come into play. They attach a

unique cryptographic hash to each artwork, which helps verify its authenticity and track its history. Artists or creators can even embed their digital signature within the NFT, which really emphasizes the originality of their creations. While digital art can be duplicated, NFTs make sure that every tokenized version is distinct and owned solely by the buyer, making it one-of-a-kind. This special quality is what draws hobbyists and collectors to digital art in the first place.

NFTs have really changed the game for artists by allowing them to earn ongoing royalties every time their artwork is resold. This was a tough challenge before, especially with physical art, where keeping track of ownership changes was no easy feat. Thanks to the NFT model, artists now have new ways to make money, turning digital art into a much more profitable field. A prime example of this is Mike Winkelmann, better known as Beeple, who made headlines when he sold an NFT artwork for a staggering USD 69 million at Christie's, setting a record for the highest art sale ever.

B. Licenses and Certifications

NFTs can be linked to specific licenses and certifications, making administrative tasks smoother and helping to cut down on fraud. Organizations often invest a lot of time in verifying educational qualifications, professional certifications, and other credentials. With NFTs, there is a more streamlined approach where each document is created as a unique, verifiable token on the blockchain. This not only makes it tamper-proof but also super easy to trace.

Take Zastrin, for example. This educational platform is shaking things up by using NFTs to give students access to programming courses and to hand out course completion certificates. These certificates, built on blockchain technology, cut out the hassle of paperwork and make sure that credentials are secure and can’t be faked. As more schools and institutions jump on board with this method, we might just see NFTs become the go-to solution for trustworthy digital credentials.

C. Collectibles

When it comes to collectibles, one of the earliest and most well-known examples is CryptoKitties. Launched back in 2017, CryptoKitties brought to life the idea of unique, breedable digital pets that users could collect and trade. Each CryptoKitty boasts its own special genetic makeup, which affects traits like fur patterns and eye color. Players have the fun opportunity to breed two kitties together to create a brand-new, one-of-a-kind NFT offspring.

The rise of CryptoKitties really put the Ethereum network to the test, highlighting just how much people crave NFT-based collectibles. The worth of each collectible hinges on things like its uniqueness, rarity, and breeding history. As NFTs keep evolving, the world of digital collectibles has grown to include trading cards, sports memorabilia, and branded merchandise, making NFTs a recognized player in the mainstream digital asset scene.

D. Boosting Gaming Potential

NFTs have truly transformed the gaming world by giving players real ownership of their in-game assets, creating decentralized game economies, and opening new ways for gamers to earn from their experiences. In traditional gaming, players are stuck with virtual items that belong solely to the game, which means they cannot sell or trade them outside of that environment. But with NFT-based gaming, everything changes. It allows for the tokenization of in-game assets like skins, weapons, characters, and even land, making them easily tradable across different platforms.

In NFT-based games, players can sell their virtual assets for cryptocurrency, which means they could make a profit if the value of those items goes up over time. This creates a play-to-earn model, allowing players to earn money through various in-game activities. Take Axie Infinity, for example—players can collect, breed, and battle digital creatures known as Axies, earning in-game tokens that can be turned into real cash. Likewise, platforms like Decentraland and The Sandbox let users buy, sell, and develop virtual land as NFTs, building virtual economies that hold real-world value.

When it comes to NFT gaming, it is not just the players who reap the rewards, game developers do too! Every time an NFT is sold, the original creator earns a royalty, which means developers can enjoy a steady stream of income whenever in-game assets change hands. This mutually beneficial business model creates a win-win situation for both players and developers, helping to foster a thriving gaming ecosystem. As blockchain gaming continues to expand, NFTs are set to transform the industry, giving players more control, financial perks, and exciting new experiences.

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The system runs on a well-organized and structured process. First, users enter their symptoms into the interface. This information is collected and matched against a vast medical database that covers a variety of illnesses and their treatments. After that, the system interacts with the NFT market. This means that if the developers decide to stop supporting a game, the items that players have collected will still belong to them.

E. Virtual World

In virtual environments, blockchain technology lays down a decentralized groundwork for a variety of digital activities [23]. Unlike the traditional financial system, where asset valuation often hinges on third-party auditors or rating agencies—resulting in hefty costs and inefficiencies—blockchain offers a more streamlined approach. This reliance on external parties can leave many assets undervalued or inaccurately assessed, which ultimately shakes investor confidence.

In the digital realm, everything from assets to transactions is logged on the blockchain, which guarantees transparency, security, and trust. This is especially important for projects in the metaverse, virtual real estate, and digital economies, where blockchain-based NFTs play a crucial role in establishing ownership and verifying digital assets.

4. Literature Survey

Ante, Lennart, The Non-Fungible Token (NFT) Market and Its Relationship with Bitcoin and Ethereum (June 6, 2021). This paper highlights how NFTs have completely changed the game for managing digital assets. In the past, owning digital assets was a tricky concept, but NFTs have made it possible. Additionally, this paper outlines the technologies needed to create a successful NFT marketplace.

Khan R. Kothari, M. Patel, and N. Banoth delve into the world of Non-Fungible Tokens (NFTs) in their paper titled "Enhancing Non-Fungible Tokens for the Evolution of Blockchain Technology," presented at the 2022 International Conference on Sustainable Computing and Data Communication Systems (ICSCDS). This paper aims to offer a comprehensive overview of NFTs, covering everything from their applications and how they work to the processes involved in buying, creating, and selling them. The fusion of NFTs with the Metaverse marks a remarkable leap forward in both virtual reality and blockchain technology, providing artists with an exciting new platform to showcase their unique and valuable creations.

Regner, Ferdinand, Schweizer, André, & Urbach, Nils (2019). NFTs in Practice – Non-Fungible Tokens as a Core Component of a Blockchain-Based Event Ticketing Application.

This paper explores how NFTs are being widely embraced across various sectors, all thanks to the Ethereum blockchain. It also offers a side-by-side comparison of different NFT marketplaces that operate on the Ethereum Main net.

Wang, Gang & Nixon, Mark (2021). SoK: Tokenization on Blockchain. DOI: 10.1145/3492323.3495577. Blockchain is an exciting technology that has the potential to change the game across various fields, including cryptocurrencies, supply chains, and the Internet of Things. At its core, blockchain technology revolves around the need to effectively manage different kinds of digital assets and data.

The upcoming blockchain ecosystem is set to showcase a variety of applications, each offering a distinct way to represent digital assets. However, since digital assets cannot be directly logged onto the blockchain, they need to go through a tokenization process to be properly formatted.

4. Proposed System

Polygon is a speedy and secure decentralized digital asset exchange that runs on a high-performance matching engine utilizing distributed consensus. It boasts a dual-chain architecture, allowing users to create digital assets and decentralized applications all on one blockchain. With Polygon, you can enjoy quick trading and exchange services while also benefiting from enhanced flexibility and programmability.

On the other hand, Pinata is a well-known platform for uploading and managing files on IPFS, offering secure and verifiable file storage specifically for NFTs.

ERC-721 is a standard interface that enables wallets, brokers, and auction platforms to interact with any NFT on Ethereum and Polygon. It accommodates both straightforward ERC-721 smart contracts and those that manage a large collection of NFTs. This standard draw inspiration from ERC-20 but is tailored specifically for non-fungible assets, where each token is distinct and irreplaceable.

React.js (or simply React) is an open-source frontend framework created by Facebook, renowned for its virtual DOM feature. It is often used alongside Express.js as a backend service. Node.js (Node) is an open-source development platform that allows JavaScript code to run on the server side. It is especially beneficial for applications that need a constant connection between the browser and the server, like real-time chat, news feeds, and web push notifications.

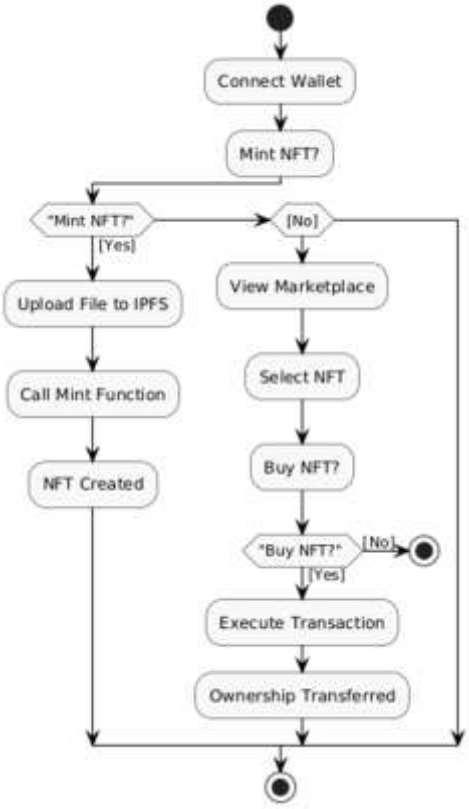

Fig-1: Flowchart depicting the user journey for minting or purchasing an NFT, including wallet connection, IPFS upload, minting, and transaction execution.

4. Architecture

The architecture of an NFT marketplace is quite like that of software architecture. It serves as a blueprint that outlines the processes and essential tasks that need to be carried out.

In this setup, let us dive into how to create a digital asset or NFT artwork on a marketplace, which essentially involves minting your own digital token. To get started, a user needs to upload the details about the NFT (the artwork) and then mint a new token.

This process involves three key steps:

- Connecting Your DApp with a Web3 Wallet: To mint an NFT on a blockchain, the first thing you need to do is connect your DApp to a Web3 wallet, such as MetaMask.
- Uploading Metadata to IPFS: Next, you'll want to upload your NFT's metadata to IPFS (InterPlanetary File System). This metadata includes all the essential details like the NFT's assets (image, video, GIF), title, description, and properties. Since we are creating a non-fungible token, it is crucial that this metadata is permanent and decentralized. That is why IPFS is the ideal choice. If you were to store these files in a centralized database, you would be exposing yourself to security risks. Once you upload your NFT's metadata to IPFS, you will get a metadata ID (IPFS key) in return.
- Minting Your NFT: Now, take that metadata ID from IPFS, use it as the token URI, and sign the transaction to mint your NFT.
- Listing the NFT for Sale: Finally, you can list your NFT for sale!

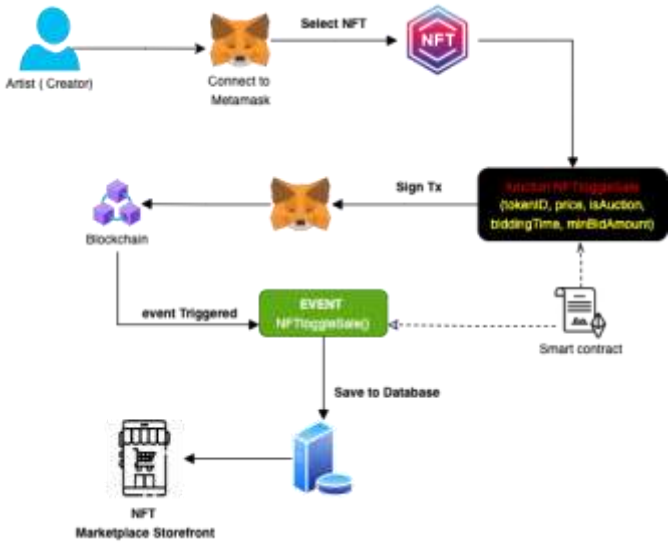

Fig-2: Workflow of toggling NFT sale using smart contract interaction via MetaMask and blockchain components.

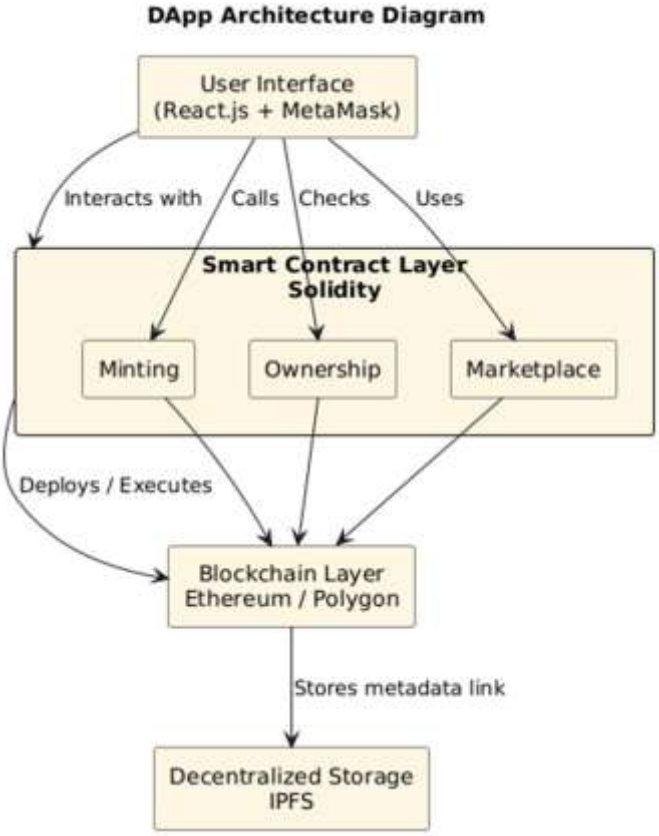

Fig-3: DApp architecture diagram showing interaction between the user interface, smart contract layer, blockchain network, and decentralized storage.

5. Future Scope

The main goal of the system we have developed is to seamlessly connect with decentralized finance (DeFi) protocols. This integration allows for liquidity and facilitates the lending and borrowing of NFTs. By harnessing the power of artificial intelligence and machine learning algorithms, the system aims to improve NFT valuation and offer valuable insights for both buyers and sellers.

To broaden the horizons of NFT marketplaces, the system accommodates a diverse array of digital assets, such as gaming items, music, and collectibles. Plus, it includes social media features that foster better engagement and communication among NFT creators, buyers, and sellers.

In response to environmental concerns, the system adopts eco-friendly solutions to reduce the carbon footprint associated with NFT transactions. All in all, this developed system strives to boost the functionality, accessibility, and sustainability of NFT marketplaces.

6. Conclusion

NFTs are created using blockchain technology, particularly on Ethereum, which makes them transparent, traceable, and secure. This unique feature of having one-of-a-kind tokens has opened new possibilities that we had not seen before, like owning digital assets exclusively. Each asset's ownership can be tracked, which boosts its authenticity. The concept of owning a genuine digital asset—whether it is an image, GIF, video, or piece of music—has captured the attention of art collectors and enthusiasts alike, sparking a rapid expansion in the market.

But NFTs are not just for digital creations; they can also be linked to physical artworks, enabling the trade of tangible items just like their digital versions. There are many platforms out there that make it easy to buy and sell NFTs across various media. Plus, their application has spread into other fields, such as education, where NFTs are used for licenses and certifications, fashion, where they help differentiate each item, and sports, where innovative revenue streams are being created through basketball card NFTs.

The growing popularity of NFTs brings along a host of challenges. These include the absence of universal security standards for smart contracts, confusion around intellectual property rights, risks of fraud through artist impersonation, and transparency issues that can compromise user security and privacy. Plus, there are significant environmental concerns due to the high energy consumption associated with these technologies.

Fortunately, there are practical solutions to many of these problems. For instance, zero-knowledge proofs (ZKP) can enhance privacy, non-browser wallets can offer better protection for crypto assets, and shifting blockchain development to more eco-friendly platforms like SolarCoin and BitGreen is a step in the right direction.

However, these solutions have not yet gained traction within the broader blockchain community, leaving many challenges unresolved. Given the immense potential of NFTs, the marketplace for them is expanding rapidly.

ACKNOWLEDGEMENT

We are grateful to the School of Engineering & Technology, Dayananda Sagar University, for the opportunity to pursue our Bachelor's degree and for supporting us throughout our project journey. Our sincere thanks to **Dr. Udaya Kumar Reddy K R**, Dean, School of Engineering, and **Dr. Girisha G S**, Chairman, Computer Science and Engineering, for their invaluable guidance and encouragement.

We would especially like to thank our project guide, **Dr. Shreekant Salotagi**, Associate Professor, Computer Science and Engineering, for his continuous support and insightful feedback. We also extend our appreciation to the Project Coordinators, faculty members of the CSE department, and all others who assisted us. A heartfelt thanks to our family and friends for their unwavering support throughout this endeavor.

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