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# Non-Fungible Tokens (NFT) – Overview, Analysis, Application and Challenges

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**Abstract**:

The Non-Fungible Token (NFT) is getting popular as skyrocket. This blockchain based digital / virtual properties with the unique identification originated from a token standard of Ethereum. The objective is to distinguish each token with unique signs. With NFTs, all marked properties can be traded with the customized values like age, rarity, liquidity, etc. NFT has greatly simulated the prosperity of the decentralized application (DApp) market. Multifold returns increasing market attention worldwide and reached sell and trades in trillions. The evolving technology is in its early stage and need solutions for technical components, protocols, standards, and desired properties. In this paper we gave technical analysis of components, design models, its properties, evaluate the security of the current NFTs with its opportunities, and challenges.

***Index Terms - Blockchain, NFT, Distributed Ledger, DApps, Smart Contract***

## 1. Introduction

NFT stands for non-fungible token. NFTs are unique certificates of authenticity on blockchain that are usually issued by the creators of the underlying assets. These assets may be digital or physical in nature. NFT is unique and can't be replaced with something else. To understand more about NFT, let's go through a bit of background.

History – the most common buzzword "Blockchain" is the one who initiated the term 'coin'. A unknown person / team named Satoshi Nakamoto published a white paper "Chain of Blocks" in 2008 to track and secure the system over time and name it as Blockchain. Distributed ledger built on this idea. Bitcoin is the first application of this technology and has single token.

Like traditional fiat currency / cash, Bitcoin is also fungible – i.e., you can trade one bitcoin with another bitcoin without changing its value. Non-fungible meaning it is unique and cannot be replaced with something else or something similar, making it suitable for identifying something or someone in a unique way.

Many other blockchain based cryptocurrencies are introduced with the same basic ideas and new capabilities. Ethereum is one of the cryptocurrencies with general purpose computation to the blockchain consensus model enabling "programmable money". Ether, the native token of Ethereum can store the value and pay for computation in the form of gas. Ether is also fungible, but its smart contract computation model allows for own token creation and can have special properties according to the logic in the contract.

## 2. What makes a token non-fungible?

With the unique serial number, one can distinguish fiat currency notes (bill). But still these two currency notes are fungible as, they are having same value as currency. By allowing each token to contain a small amount of arbitrary data, NFTs become a medium for creative express, as well as a unit of exchange and account. Thus, the value of an NFT is highly dependent on the data it contains

and represents. By using NFT on smart contract, a creator can easily prove the existence and ownership of the digital assets in the form of videos, images, arts, event tickets etc. Furthermore, royalties can be earned for trading or peer-to-peer exchange on any NFT market. Complete history tradability, deep liquidity and convenient interoperability enable NFT to become a promising intellectual property protection solution.

NFTs has risen rapidly since 2020 and has become one of the most popular application in industrial and scientific communities. NFTs are transferrable rights to digital assets, such as art, in-game items, collectable or music, anything that is unique or rare. According to CoinMarketCap [1], the global crypto market volume for 24 hours crossed to 1.31 trillion USD while 24-hour trading volume on average of NFT market is 3 Billion and will cross 13.6 Billion by end of 2027. [ 2] this proves the growing interest in the nonfungible token (NFT) space among today's investors.

Some of the other factors which contributes to speedy growth of the NFT market is metaverse initiatives and the personalized NFTs. The sale of NFT was estimated at 12 million by December 2020 but surprisingly it exploded to 340 million by February 2021. Such stipple rising and booming development made NFT crazy and became future of digital assets.

NFTs are unique certificates of authenticity on blockchain that are usually issued by the creators of the underlying assets. These assets may be digital or physical in nature. Prominent example of non-fungible-tokens (NFT) are recorded version of *Madhushala*, curated by Amitabh Bachchan himself sold for $756000 or Twitter CEO Jack Dorsey auctioning off this first ever tween for $2.9 million (Valuables, 2021), which was published on March 21, 2006. People have expressed interest in various types of NFTs like games or trades with enthusiasm. CryptoPunks is one of the firm NFT on Ethereum. CryptoKitties promoted in 2017 with the gamification of the breeding mechanics. The high prices to auction the rare cats reached more that 999+ETH. Few NFT which achieved a great success includes – Picasso Punks, Hashmasks, 3DPunks, CryptoCats, NFT box, etc. Besides games and collectibles, NFT is getting popular in art, events, value, IoT, Finance, statistic website like – OpenSea, Radiable, DappRadar, NFT Bank, DfiPulse, Coingecko.

Though skyrocket booming impact of NFT on current decentralized markets and future business opportunities, still it is in the very early stage and need to tackle very carefully.

## 3. Technical Components

Basic building block of fully functional NFT scheme are as follows

**Blockchain** – Ethereum blockchain is the foundation technology in NFT schemes. Along with the basic properties of the blockchain like immutability, decentralized, distributed ledger, secure, consensus protocol, and private.

**Smart Contracts** – Smart contracts are programs stored on

Smart contracts are simply **programs stored on a blockchain that run automatically with immediate effect**. With the help of smart contracts only all the decentralized participants to conduct fair exchanges without intervention of third party and maintain unified method for building applications across industries. With distributed nodes the transparency and consistency are maintained in the network. Most NFT solutions rely on smart contract based blockchain platforms to ensure their order-sensitive executions.

**Address and transaction**- blockchain is based on the cryptography concept, where address is unique identifier for nodes. It consists of alphanumeric characters generated from a pair of public key and private key. To trade NFTs, one need to transfer it with the help of his/her private key and send the asset to receiver's public address with a correct digital signature. This is performed using cryptocurrency wallet.

**Data Encoding** – in the blockchain system, for the security and privacy of data, the data is encoded with the help of hash function. For NFT based intellectual property, one need to owe the original hash (hex) value singed by a creator. Others may have free copy of raw data, but they cannot claim ownership of property.

## 4. Protocols, standards, and Properties

Protocols – As NFT is blockchain based application the ledger along with basic characteristics – (security, consistency, completeness, and availability), will have two roles – NFT owner and NFT buyer. The protocol detail contains process given below

NFT Digitize – NFT owner need to check the digital file, title, description. Once done digitize this raw data into a proper format.

NFT Store – An NFT owner stores the raw data into an external database off-chain.

NFT Sign – NFT owner signs a transaction which includes hash of NFT data and send it to a smart contract.

NFT Mint&Trade – once owner sign a transaction then minting and trading process begins.

NFT Confirm – once the transaction confirmed, the minting process completes. Thus, NFTs will forever link to a unique blockchain address and their persistence and immutable evidence.

**Token Standards –** token standards have a great impact on the ongoing NFT schemes. Token standards those are related to NFTs are – ERC-20, ERC-721, ERC-1155.

ERC-20 – introduced the concept of fungible token for the Ethereum based applications. The most prevailing tokens based on ERC-20.

ERC-721 – introduced a non-fungible token standard which is unique and can be distinguished from another token. In this tokenId can be used to generate special identifications.

ERC-1155 (Multi Token Standard) – provides an interface that can represent any number of tokens. ERC-1155 extends the functionality of tokenId, where each of them can independently represent different configurable token types and can represent both fungible and non-fungible tokens. The fields may contain its customized information like metadata, lock-time, date, supply, or any other attributes.

**NFT desired Properties** – NFT schemes are based on decentralized blockchain application and have all the properties of distributed public ledgers. Key properties are mentioned as follows:
Verifiability – token metadata and ownership of NFT can be publicly verified
Transparency – all the activities in the distributed network like NFT minting, selling and purchasing are publicly accessible
Availability – NFT system is available 24x7 for sell and buy
Tamper resistance – once the transaction is confirmed, no one can alter record in the system.
Usability – NFT system is up-to-date, user friendly and transparent.
Atomicity – all the processes in the system are atomic and has same execution state
Tradability – every NFT and its products can be traded or exchanged.

## 5. System Analysis

NFT system is a combination of technologies – blockchain, storage and web application. Since any component may become an attacking interface, so security analysis is challenging. Few potential issues are investigated here and proposed defense measures.

**Spoofing** (authenticity) - Issue – a malicious attacker may steal the user's private key to transfer the ownership of NFTs illegally. Proposed solution to avoid this to verify user with the help of smart contract and cold wallet can be used to prevent private key leakage.

**Tampering** – blockchain is a robust public transaction ledger which cannot be altered. Metadata and ownership of NFT is impossible to manipulate once the transaction is completed. However, data stored outside the blockchain may be modified. To avoid this, it is proposed to send both the original data and hash data to the NFT buyer at the time of NFTs trading.

Repudiation (non-repudiability) - relative to non-repudiation, repudiation means that **the creator or owner of the NFT cannot refuse or withdraw once the transaction information is confirmed on the blockchain**. The security of this process is guaranteed by the qualities of the blockchain distributed ledger and the unforgeable signatures. The purpose of non-repudiation service is to collect, maintain, provide, and verify the undeniable evidence about messages from the transmitter to the receiver. However, the has data may be stolen by the malicious attacker, or hash data may bind with the attacker's address. To avoid this, it is proposed to use a multi-signature contract to solve the issue to some extent. With this each binding must be confirmed by more than one participant.

**Information disclosure** – for the transparency reason, state information and instruction code are kept transparent in NFTs smart contract which is publicly available for the observer. So, to protect user's privacy, it is recommended to use privacy-preserving smart contracts.

**Denial of Service (DoS)** – Dos attack is a type of network attacks in which a malicious attacker violates the availability and break down the NFT services for the user and use the same for unauthorized activities. Blockchain guarantees data availability and can be restored as when required. However, centralized application, web application or raw data outside the blockchain may get affected resulting into D0S to NFT service. With the recent hybrid blockchain architecture with two algorithms and comparative weak consensus solve this availability issue.

**Elevation of Privilege** – this property is related to authorization. As selling permission in NFT system are thoroughly managed with smart contract, poorly designed smart contract may arise threat and attacker may gain permission to access the NFTs.

## 6. Opportunities

With the rise of NFTs, several typical fields getting benefits. Few of them mentioned below-
**Boosting game industry** – NFT is getting most popular in gaming industry. Crypto games like CryptoKitties, Cryptocats, CrtyptoPunks, Meebits, Axie Infinity, and few of the popular games. With the fascinating feature like breeding, along with raising pets and spending time with them, user can breed new offspring too. Users can buy limited or rare edition virtual pets and then sell them at a higher price and earn profit. This is one of the main attractions in NFT prominence. NFT publishers can earn royalties each time their items are traded in open market. This way NFT market is mutually beneficial business model and largely extending that covers different types of digital assets.

**Flourishing virtual events** – apart from the small range of events of raising money like ICO (Initial Coin Offering) / IFO (Initial Farm Offering) / IEO (Initial Exchange Offering), NFTs has extended the scope of blockchain applications with the additional properties like uniqueness, ownership, liquidity. With the help of these properties, user can link to a specific event in the real life. For an example, while buying a ticket in a traditional event ticket market, consumer need to trust the third party which may result into risk of fraudulent or invalid tickets or same ticket may be sold multiple times. NFT based ticket represents a ticket issued by the blockchain to demonstrate entitlement to access to any event like culture or sports. An NFT based ticket is unique and scarce, so that the ticket holder cannot resell the ticket once it is sold. The blockchain based smart contract provides a transparent ticket trading platform for event organizer and customers. Stakeholder can buy and sell the crypto ticket from the smart contract in an efficient and reliable way.

**Protecting digital collectibles** – digital collectibles may be anything precious or unique like digital image, videos, virtual real estate, domain names, diamond, stamps, cards, wines, and other real or intellectual properties. Let's consider the case of artist. Traditionally, artist need to display the works on different channels and need to bear intermediary fees for platforms and advertisements. Due to lack

of attention, they may not get true value of their works. With the help of NFT, they impetus with lots of profits. NFTs transform their work into digital formats with integrated identities with secured ownership and contents with the artist. Furthermore, with NFTs artists receives predetermined royalty fee each time this digital artwork is traded in the market. SuperRare, MakersPlace, Rare Art Lab are several platforms for trade. In addition, Mintbase, Mintable are the platforms where ordinary people can create their own NFT.

**Inspiring the Metaverse** – Metaverse include virtual reality characterized by persistent virtual worlds and augmented reality that combines aspects of the digital and physical worlds. Blockchain provides a decentralized environment for the virtual online worlds. As of now it is in an early stage due to complexity. But majority of youth is fascinating towards this blockchain-fueled alternative reality and enjoying games, trading assets, arts, virtual properties and gaining profits from this virtual economy.

## 7. Challenges

Blockchain is comparatively very young technology and NFT is its extension. Skyrocket booming development made NFT crazily popular but still have few barriers / limitations to overcome. There are many challenges like security, governance, extensibility which includes system level issues caused by blockchain-based platforms and human factors like governs, regulation and society.

### Usability Challenge

Slow confirmation and high gas prices – As NFT system is blockchain based application so for confirming particular transaction in the network, to get approved from all the nodes, it is taking time. (Bitcoin – TPS, Ethereum -30 TPS which is relatively very slow). And to make this transaction faster, you need to pay high gas price. As of now to mine a simple NFT token it costs USD 60.

**Security and privacy Issues** – data security is the priority of any system. Anonymity and privacy of NFTs are still understudies. Ethereum platforms only provide pseudo-anonymity. Many privacy preserving solutions have not yet applied to NFT related schemes. Another challenge is NFT data inaccessibility. To save gas consumption, data might be stored off-chain and related to on-chain by tagging with token. When the data is stored off chain rise the risk of intruder to change data / tags. In this case, a usr cannot prove that s/he owns the particular NFT.

**Government Consideration –** similar to all other blockchain based applications, there is no control of any government or third party for NFT also. So, regulating this emerging technology with its huge market is a big challenge. As it is person-to-person transaction, cross border transactions, KYC (Know Your Customer) are main concerned areas. Without clear understanding of the issues related to regulatory scrutiny and litigation, it is difficult for many emerging countries to legalize the cryptocurrencies and their related applications. Exchanging, trading, selling, or buying NFTs have a big challenge of acceptance by the governance. Also, under the current legal framework all the IP related products including arts, books, domain name etc. are treated as taxable property. However, crypto and NFT based sales is out of this scope. Few countries like USA tax cryptocurrencies as property and most countries have not yet considered it. The individual participants should have the tax liability on any capital gains that are related to NFT properties. Thus, it needs to seek more advice from professional tax departments after the profound discussions.

**Extensibility issues -** As blockchain is quiet young technology and NFT is extension of Blockchain. This evolving technology is coming with lots of updates from various perspectives and have stress of whether a system can interact with other ecosystems and whether the current ecosystem can obtain updates when the current version is left behind. NFT interoperability and cross chain communication are always handicaps for the wide adoption of DApps. Except Ethereum based NFT projects share a similar data structure and can exchange under the same rules. But for crosschain communication one need to trust the external parties and may inevitably lost decentralization and privacy property to some extent. NFTs are continuously updating for better experience. These updates are soft forms (minor modifications that are compatible forwards) and hard forks (significant modifications that may conflict with previous protocols). So properly updating the system with the improvements is a necessity.

## 8. Conclusion

NFT (Non-Fungible Token) is an emerging technology prevailing in the blockchain market. The paper explores the NFT solution that re-shape the market of digital/virtual assets going forward. Paper gives - analysis of technical components and design models and properties, evaluate the security of the current NFTs with its opportunities, and challenges. This paper a channel for newcomers to keep up with the current progress.

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