

# Non-Fungible Tokens (NFT): New Emerging Digital Asset

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## Abstract

The Non-Fungible Token (NFT) market is mushrooming in the recent few years. The idea of NFT originally comes from a token commonplace of Ethereum, getting to distinguish every token with distinguishable signs. This sort of tokens will be sure with virtual/digital properties as their distinctive identifications. With NFTs, all marked properties will be freely listed with made-to-order values per their ages, rarity, liquidity, etc. It's greatly stirred up the prosperity of the suburbanized application (DApp) market. At the time of writing (May 2021), the total cash used on completed NFT sales has reached 34,530,649.86 USD. The thousandfold come back on its increasing market attracts large attention worldwide. However, the event of the NFT scheme remains in its early stage, and the technologies of NFTs are pre-mature. Newcomers might drift in their phrenetic evolution because of the shortage of systematic summaries. During this technical report, we tend to explore the NFT ecosystems in several aspects. We tend to begin with a summary of progressive NFT solutions, risk and return, then offer their technical parts, protocols, standards and desired proprieties. Afterwards, we tend to provide a security evolution, with discussions on the views of their style models, opportunities and challenges. To the most effective of our data, this can be the primary systematic study on this NFT ecosystems.

**Keywords:** Blockchain; NFT; DApp; Smart contract; Non-fungible tokens; Cryptocurrency

Date of Submission: 10-04-2022

Date of acceptance: 26-04-2022

## I. Introduction



Figure 1. A History of Blockchain Technology Source: DHL, 2018.

Blockchain technology is a radical innovation with the potential to challenge or even replace existing business models relying on third parties for trust (Beck and Müller-Bloch, 2017). The concept of blockchain was introduced in 2008 through the release of the Bitcoin whitepaper (Nakamoto, 2008) and primarily used as the technology behind cryptocurrencies during its first years. In 2014, a second generation of blockchains (e.g. Ethereum) was introduced, which allows to program and execute software – so-called smart contracts – on all participating blockchain nodes. Consequently, any user is enabled to create and deploy programs on a shared global infrastructure (Buterin, 2014; Wood, 2014). This has led to the realization of new concepts designed to simplify human interaction and collaboration on a large scale across several industries (e.g. supply chain management, international payments, international trade finance, energy markets, and notary services) (Christidis and Devetsikiotis, 2016; Morabito, 2017; Wüst and Gervais, 2017). Particularly, the use cases of Initial Coin Offerings (ICOs) that re-invent crowdfunding using blockchain and its ability to tokenize assets, is drawing public attention (Fridgen, Regner, Schweizer and Urbach, 2018). The spectacular success of ICOs, where globally an estimated 12 billion USD has been collected, has been enabled by the ERC-20 standard (AutonomousNEXT, 2018). This standard, which specifies a common interface for fungible tokens that are divisible and not distinguishable, was mutually agreed on by the developer community to ensure interoperability (Vogelsteller, 2015).

In contrast, non-fungible tokens (NFTs) differ from fungible tokens in two important aspects. Every NFT is unique, and it cannot be divided or merged (Voshmgir, 2018). This new form of token was first introduced with the ERC-721 standard in late 2017 (Entriiken, Shirley, Evans and Sachs, 2018). ERC-721 variates significantly from the ERC-20 standard as it extends the common interface for tokens by additional functions to ensure that tokens based on it are distinctly non-fungible and thus unique (Entriiken et al., 2018). For practitioners, these distinct properties of NFTs enable a variety of new use cases. It particularly improves the tokenization of individual assets which is not feasible with fungible tokens, as they cannot digitally represent uniqueness. Thus, practitioners have conducted a multitude of experiments in the past months using NFTs to represent both digital goods such as virtual gaming assets, digital artwork and software licenses as well as physical assets such as luxury goods and cars (Butcher, 2018; Griffin, 2018). NFTs are seen as key to unlock the market for collectibles which has an estimated global market size of USD 200 billion (Fenech, 2018).

In the recent years, NFTs have garnered remarkable attention from both the industrial and scientific communities. It was reported that the 24-hour trading volume on average of the NFT market is 4, 592, 146, 914 USD5 , while the 24- hour trading volume of the entire cryptocurrency market is 341, 017, 001, 809 USD. The liquidity of NFT-related solutions has accounted for 1.3% of the entire cryptocurrency market in such a short period (5 months). Early investors obtain thousandfold returns by selling unique digital collectibles. At the time of writing (May 2021), the NFTs-related market has significantly increased compared to one year ago (January 2020). Specifically, the total number of sales is 25, 729 and their total amounts spent on completed sales reach 34, 530, 649.86 USD6 . In particular, the total number of primary-market sales occupies 17, 140, while the number of secondary sales (user-to-user) is 8, 589. Correspondingly, the total USD used on primary market sales is 8, 816, 531.10. Besides, the active market wallets achieve 12, 836, which is still increasing at a high speed as time goes. Surprisingly, the sale of NFTs was estimated at 12 million (December 2020) but exploded to 340 million within just two months (February 2021). Such skyrocket booming development makes NFT become a craze, or even be described by some as the future of digital assets.

Despite NFTs have a tremendous potential impact on the current decentralized markets and the future business opportunities, the NFT technologies are still in the very early stage. Some potential challenges are required to be carefully tackled, while some promising opportunities should be highlighted. Further, even though much literature on NFTs, from blogs, wikis, forum posts, codes and other sources, are available to the public, a systematic study is absent. This paper aims to draw attention to these questions insofar as observed and focus on summarising current NFT solutions. We provide a detailed analysis of its core components, technology roadmap status, opportunities, and challenges. The contributions are provided as follows. - Firstly, we abstract the design models of current NFT solutions. Specifically, we identify the core technical components that are used to construct NFTs. Then, we present their protocols, standards and targeted properties. - Secondly, we give a security evaluation of current NFT systems. We adopt the STRIDE threat and risk evaluation [102] to investigate potential security issues. Based on that, we also discuss the corresponding defence measures for the issues. - Thirdly, we explore some future opportunities of NFTs in many fields. Applying NFTs to real scenarios will boost a wide range of new applications. We give a set of practical instances (projects) leveraging NFTs with great success or prosperous market. - Finally, we highlight a series of open challenges in NFT ecosystems. Blockchainbased NFT systems still confront unavoidable problems like privacy issues, data inaccessibility, etc. We outline open challenges existed in state-of-the art NFT solutions.

## II. Cryptocurrency

Invention of blockchain technology has triggered a new wave of technological progress, transiting many industries, methods, processes and systems that used to be the norm. Transactions on a blockchain are processed by computers which works together on a public or private network and every transaction should be confirmed. All transactions sent on blockchain are processed in blocks. Each of the block is linked to the previous block and that makes it impossible to change and alter a transaction. Moreover, this is a transparent architecture because each computer called node in the network has a record of every single transaction that has confirmed. Records can be added but cannot be altered or deleted, they are immutable. Security guarantee for cryptocurrencies is provided by math and cryptography. Securely keeping and saving data in a way that is completely transparent and verifiable through a decentralized system has been key for the rise of cryptocurrency. Cryptocurrencies have gained much attention from the experts of financial and technical sectors and academic world recently. Cryptos are not ruled, managed or governed by central authorities. According to Coinmarketcap web page, total market capitalization has surpassed 1 trillion dollar and as of June 29, 2021, and reached \$1,418,409,684,091 (Coinmarketcap, 2021).

As Bitcoin becomes more popular, many individuals may think that Bitcoin is the only crypto in the market. All coins created after Bitcoin have a generic term and called as "Altcoins". In fact, the name "altcoin" that all are created after bitcoin actually means "alternative" to Bitcoin. Although there are thousands of cryptocurrencies in the cryptocurrency market, a few of them are popular and regarded as the major cryptocurrencies because their market capitalization is much higher than the others (Aghalibayli, 2019). Moving beyond the fundamental use case of Bitcoin, Ethereum has an incredible potential and is making its name on Decentralized Applications (dApps). Here is the list of most popular top 10 coins among 10698 cryptos are shown in below table:

Name	Symbol	Market Cap
Bitcoin	BTC	\$654,030,330,565
Ethereum	ETH	\$248,319,380,015
Tether	USDT	\$62,475,376,607
Binance Coin	BNB	\$45,515,842,324
Cardano	ADA	\$42,857,089,064
Dogecoin	DOGE	\$33,482,185,763
XRP	XRP	\$30,492,490,538
USD Coin	USDC	\$25,383,636,199
Polkadot	DOT	\$15,517,991,561
Binance USD	BUSD	\$10,501,715,901

**Table 2.** Top 10 Cryptocurrencies by market cap **Source:** (Coinmarketcap, 2021)

Although most of the altcoins are built upon the similar basic framework of Bitcoin, many claim to be better versions of Bitcoin. Ethereum is an important actor among cryptocurrencies because many new tokens and dApps are already being built upon the Ethereum blockchain. According to the total market cap, Ether, which is the symbol powering Ethereum network, is in the second trading currency after Bitcoin (XRP). There is a fixed, limited number of Bitcoins that can be created and exist which is 21 million. That number decided by the creator/s of Bitcoin at the beginning of project. Like Bitcoin, most cryptocurrencies listed here have a fixed supply except Ethereum. Ethereum has unlimited supply. Ethereum has been created in 2015 (Srhir, 2019). Both of these cryptocurrencies are created with open-source computing codes, which means their codes can be viewed and used by anyone. Ethereum builds on Bitcoin's innovation, with some big differences.

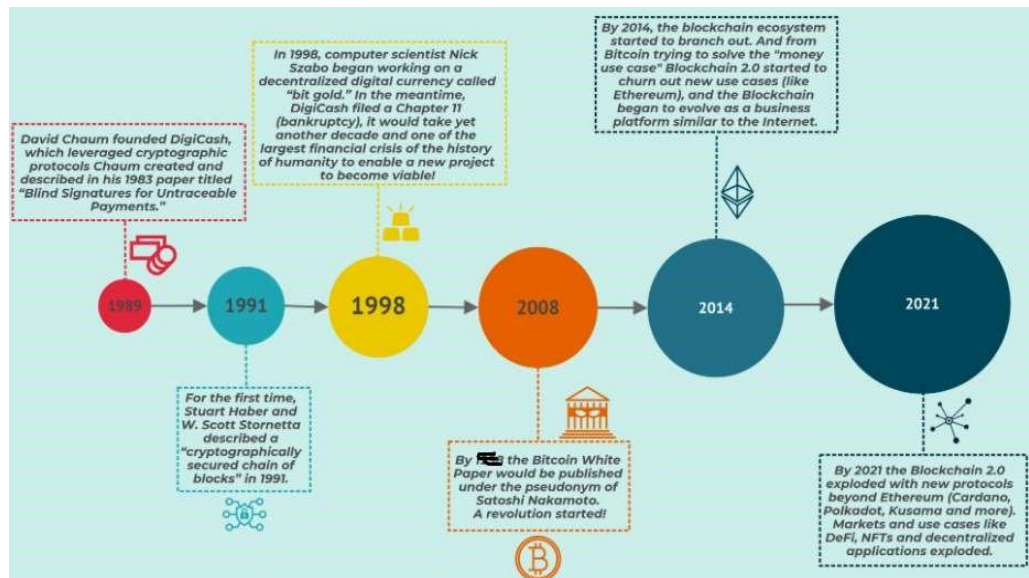


Figure 2. Evolution of Cryptocurrencies Source: Cuofano, 2021.

### III. What are Non-Fungible Tokens?

This brings us to non-fungible tokens (NFTs). What are they, and how are they different from non-fungible digital assets like domain names or Twitter handles? Non-fungible tokens are an extremely powerful kind of token that allows for a flexible way to represent non-fungible assets on a blockchain. Their main properties are: Unique: Non-fungible tokens contain within their code information that describes the properties of each token that make them different to others. A piece of digital art might have coded information about individual pixels, while tokenized in-game items might contain details that allow the game client to understand which item the player owns and its attributes.

**Traceable:** Each NFT has a record of transactions on-chain, from when it was created, including every time it changed hands. This means each token can be verifiably authentic, and not a counterfeit – obviously a very important thing for owners and prospective buyers!

**Rare:** For non-fungible tokens to be attractive for buyers, they should be provably scarce. This will ensure that assets remain desirable in the long run, and that supply does not outstrip demand.

**Indivisible:** NFTs mostly cannot be transacted as fractions of a whole. Just like how one cannot purchase half of a concert ticket or trading card, non-fungible tokens cannot be split into smaller denominations.

**Programmability:** Like all traditional digital assets and tokens built on smart contract blockchains, NFTs are fully programmable. CryptoKitties and Axie Infinity have breeding mechanics coded directly into their tokens. Even more functionality is possible.

In other words, NFTs combine the best traits of decentralized blockchain technology with non-fungible assets. Unlike regular digital assets that are issued and regulated by centralized entities, which can be taken from you at any time, it is possible to truly own and control your own NFTs.

In another words, non-fungible tokens are cryptographic assets created mostly on Ethereum blockchain with unique identification codes and metadata that makes NFTs distinguish from each other. The table below shows top 10 NFT coins by market capitalization by Coingecko (Url-6, 2021). NFTs can't be traded or exchanged at equivalency unlike cryptocurrencies, because they are not "fungible" (Sharma, 2021). Detailed model of NFT systems is shown below Figure 4.

Name	Symbol	Market Cap
Theta Network	THETA	\$7,364,196,518
Tezos	XTZ	\$2,465,935,638
Chiliz	CHZ	\$1,385,584,301
Enjin Coin	ENJ	\$1,044,463,535
Decentraland	MANA	\$741,926,850
Flow	FLOW	\$453,847,508
Ecomi	OMI	\$424,239,427
Ultra	UOS	\$423,975,468

BakerySwap	BAKE	\$353,014,298
Axie Infinity	AXS	\$249,011,623

Table 3. Top 10 NFT tokens by market cap Source: (Coingecko, 2021)

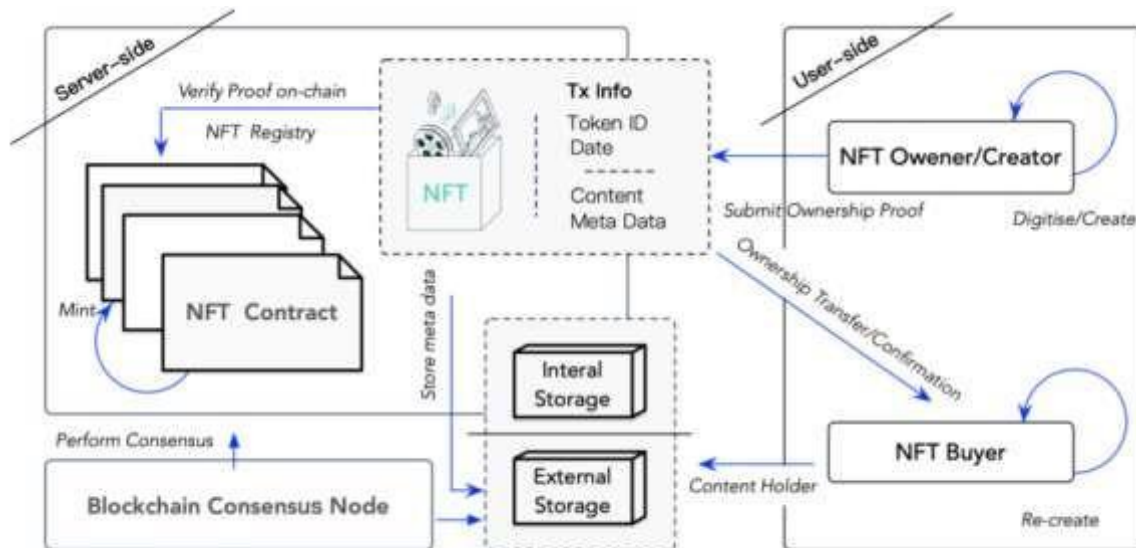


Figure 4. Model of NFT Systems Source: Wang et. al, 2021

The first example of NFTs is CryptoKitties, a blockchain game on Ethereum that allows players to purchase, collect, breed and sell virtual cats in 2017 (Url-7, 2021). While the gaming industry's adoption has already reached a certain maturity, the production of digital content such as music, digital art or video, are experimenting with the technology. In December 2020, the market of NFT art started to grow again. The NFT volume has exceeded 2 USD billions, ten times larger than the entire trading volume in 2020, just in the first four months of 2021 (Url-8, 2021). And NFT market attracted a huge attention in March 2021, when the artist known as Beeple sold an NFT of his work called “Everydays: The first 5000 days” sold for \$69.3 million at Christie’s, a single-lot sale that marks the first time a purely digital work of art (Url-9, 2021). Following days, three Cryptopunks were sold at \$7.5 million, \$1.54 million and \$1.3 million dollars, respectively; the first tweet of the Twitter CEO Jack Dorsey was sold at \$2.9 million dollars to Sina Estavi; and the Auction Winner Picks Name, an NFT with music video and dance track, sold at \$1.33 million dollars (Phillips, 2021). NFTs profitability has attracted several celebrities, who created their own NFTs, as well as the most popular sports, with collectibles of NBA and famous football players that are currently sold for hundreds of thousands of dollars (Devlin, 2021).

#### IV. NFTs and ownership

Blockchains operate under the principle of “code is law”. From the blockchain perspective, the creator of the token, to which an asset is attached, is initially the owner of the token. Anyone who buys that token owns the hash. In this way, they own the token. This shows that ownership of NFTs is transactional. It can be simple ownership of the NFT or additional ownership and the same can be encoded in the underlying smart contract. Thanks to the blockchain, and distributed ledger technology, the sale and movement of NFTs can be traced, verified and recorded on an immutable ledger. This means that their creation, unique identifiers, and ownership is not only traceable, but also verifiable. Digital collectibles, artworks and intellectual property are likewise protected, as each item can be traced to its origins. This means digital collectibles can be authenticated and verified, protecting both the creators and the owners from scams and fakes. NFTs provide proof of ownership of the asset, real or virtual, attached to the token which the token holder can use at his/her own discretion to provide an immutable and verifiable record of ownership which can be transferred at the owner’s behest.

In different use cases, ownership can constitute different meanings. For example, a copy of a digital photo that was minted on a platform can be made available on a different platform while the ownership of the image remains with the NFT token holder. In the music industry, holding an NFT of an album can constitute ownership of that album, the proceeds from which will go to the NFT owner.

## V. Conclusion

We have examined NFTs as an arising sensation and assessed NFTs as a core constructing obstruct for a blockchain-based occasion ticketing system. We complied with a style scientific research method based upon the standards by Hevner et alia. (2004) and iteratively designed a model. With the procedure of developing, constructing, and assessing the NFT-based model, we had the ability to produce a number of appropriate searchings' for concerning advantages and difficulties of the new token kind. We discovered that NFTs can assistance to conquer the present weak points of current non-blockchain occasion ticketing systems, such as vulnerability to scams, absence of manage over second market deals and recognition of possession. Additionally, our searchings' for suggest that using NFTs presently positions a number of difficulties, mainly acquired from the hidden blockchain procedure. Since we have revealed that deal with services to conquer these difficulties is presently in development, we suggest additional research study to re-assess the specify of these difficulties in the future.

A potential limitation of this study and at the same time an exciting challenge for future research is the topic of NFT wash trading. This is an issue that poses significant challenges to blockchain-based pseudo-anonymous markets and cryptocurrency markets (Cong et al., 2020; Le Pennec et al., 2021). In principle, an owner or creator can trade her own NFT transparently but anonymously by transferring it between two different addresses/wallets on the public blockchain infrastructure. This way, demand can be suggested, faked or inflated with the goal to attract future buyers. The legality of any such behaviour is currently unclear. If it were to take place, this could— besides the evident investor protection challenges—bias the statistics on NFT sales and wallets and their interpretation used in this study. Accordingly, future research might analyze (large) NFT sales, the blockchain addresses involved, and transaction patterns to identify any wash trading.

We agree with Dowling's (2021a) main conclusion "that NFTs do appear to be a distinct (and exciting) new asset class". While the NFT market still seems to depend on the cryptocurrency market, specifically BTC, it may well mature over time. The question is to what extent this relationship will change once traditional marketplaces such as eBay allow trading of NFTs (against fiat currencies or stablecoins) (Reuters, 2021), established companies such as Instagram fully appreciate the potential of NFTs (Keely, 2021), or media firms like Fox launch their own NFT ventures (Khatri, 2021). In the future we may see NFT submarkets that are strongly related to cryptocurrency markets and others that are much more independent. The further development of the NFT market and its relationship to the cryptocurrency market thus holds plenty more research interest

In spite of these restrictions, our research study is just one of the initially clinical tries to deal with the concerns if NFTs work in exercise and how they can assistance to enhance current systems in real-world domain names. The important understandings we produce for specialists are threefold: Initially, we emphasize the distinctions in between NFTs and fungible symbols and offer finest methods for the advancement and assessment of systems utilizing NFTs. 2nd, we show the effectiveness of NFTs for the utilize situation of occasion tickets and offered evidence by building with an effective application of a functioning model (Hevner et alia., 2004). 3rd, we fancy on the repercussions of its utilize and emphasize useful difficulties. Along with these useful understandings, we include detailed understanding to an arising area of research study where clinical researches are limited. We prolong and enhance current researches in the literary works on blockchain innovation by including new finest exercise methods on ways to develop and assess a blockchain-based system utilizing DSR (Glaser, 2017). Lastly, our research study functions as a structure for future academic and useful research study on NFTs, allow various other scientists to make use of its searchings for and develop concepts and lay ground to higher-theory advancement (Gregor, 2006).

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