

Demystifying Non-Fungible Tokens (NFTs)



About this report

This thematic report is part of a series of reports that will be published addressing selected topics in accordance with the European Commission priorities. The aim is to reflect on the latest trends and developments and discuss the future of blockchain in Europe and globally.

Credits

This report has been produced by the EU Blockchain Observatory and Forum team. Written by:

- Nikos Kostopoulos, Tonia Damvakeraki, INTRASOFT International
- Lambis Dionysopoulos, Marianna Charalambous, George Giaglis, IFF – University of Nicosia
- Zalan Noszek, Bitfury
- Ishan Roy, Janis Graubins, Daniel Szego, Alexi Anania, Ash Costello, Jeff Bandman EU Blockchain Observatory and Forum Expert Panel

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Note

While we have done our best to incorporate the comments and suggestions of our contributors where appropriate and feasible, all mistakes and omissions are the sole responsibility of the authors of this paper.

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Chapter 1: Demystifying Non-Fungible Tokens

1.1 Overview and Definitions

Nearly a century ago, the philosopher, cultural critic and essayist Walter Benjamin wrestled with the transformation of “The Work of Art in the Age of Mechanical Reproduction.” While art always could be, or had been, imperfectly imitated or reproduced – by apprentices, pupils, studios and counterfeiters, new forms of technology such as photography and film accelerated the efficiency and fidelity of reproduction. This development brought into question the meaning of “originality” and “authenticity” and separated the reproduced work from the “aura” of its original. Today, we live in an age of digital reproduction, where a few simple clicks or lines of code can generate perfect facsimiles, improved copies, or even “deep fakes” that never existed.

Yet the immutable blockchain ledgers introduced with Bitcoin, Ethereum, and other cryptocurrencies, and utilised by non-fungible tokens (NFTs), are enabling new forms of originality, and most critically, provable originality and authenticity coupled with provable ownership and powerful programming capabilities. Just as bitcoin solved the “double spending” problem in our age of digital reproduction, today NFTs are beginning to enable new forms of originality while starting to transform legacy forms and concepts of ownership and provenance. An NFT may exist only digitally as the product of programmable code, smart contracts and technological protocols, yet retain its aura and originality.

NFT Definition

An NFT is a special type of digital asset or token that can be proved to be unique and not interchangeable with another digital asset token (i.e., fungible). This is why it is referred to as a “non-fungible token”. Typically, the record of the uniqueness of the NFT exists as a cryptographic record on a blockchain, or distributed ledger, and can readily be viewed by anyone. While that is not always the case, NFTs are not just digitised information about an asset – they are a digital asset. This parallels the way that the blockchain constitutes the internet of value.

To better understand the concept, it is helpful to contrast an NFT with a fungible token or asset. Fungible tokens, which are the most in the blockchain realm, are tokens in which one has the same characteristics as any other, and thus can be easily replaced by any identical token. The most familiar illustration of a “fungible” asset is cash as a 10 Euro note can be interchanged by any another 10 Euro note. Conversely, real-world examples of non-fungible assets include tickets to events, legal records of asset ownership such as titles to a property, as well as artworks or collectibles.

NFTs are created in accordance with certain frameworks or standards and deployed on-chain. At the moment, the most popular blockchain for NFTs is Ethereum, and the most standard Ethereum’s ERC-721, which determines certain characteristics for NFTs. In this way, NFTs can be managed, traded, and owned in accordance with the properties of the framework or protocol as those have been defined according to their issuance properties.

Characteristics of NFTs

While it is impossible to account for every variation and standard, we can identify some widely accepted and foundational characteristics that are shared amongst most NFT deployments. These include uniqueness; transparency and provability of ownership; asset programmability; and immutability of records.

- a. **Uniqueness:** With NFTs it is possible to produce a limited number of tokens, with each being individually identifiable. A popular example are the 10 000 unique NFTs issued by CryptoPunks. Though in some cases having similar NFTs is plausible, as is the case with numbered series of an artist’s digital work. A good way of thinking this is the analogy of 1:1:X, or one, out of one, out of X.

- b. **Rarity:** Rarity in NFTs can come in many forms and can be either artificial, numerical or historical.
 - i. Artificial rarity refers to the uniqueness of the NFT as determined by its code, or the specifics of its issuance. To better understand this concept, we can again utilise the popular Cryptopunks. As determined by their issuance, only 1.75% of the total Cryptopunks have a Medical Mask feature. Contrasting this with the 24.59% chance of having an Earring, we can denote that a punk with a Medical Mask will always be rarer than the one with the Earring, if all else is equal.
 - ii. Numerical rarity is closely tied to Artificial and as such, is relatively intuitive to understand. Consider the example of a popular artist releasing 100 digital copies of their latest music album as NFTs. Intuitively those 100 copies that come with the artists “digital signature” and can be verifiably owned, will be more scarce and thus rare, than simply streaming the album off Spotify. It is useful to think of this as the analogous of owning a physical album that is signed by the artists, and one that is not.
 - iii. Finally, historical rarity refers to the historical significance of an NFT. This comes in many different forms. For example, part of the allure of Cryptopunks is that they were some of the first generative NFTs ever issued, thus they are special in that sense. Moreover, since blockchains record an immutable history of ownership, some NFTs might be historically significant, as they were owned by notable entities or individuals. This is analogous to how Stevie Ray Vaughan’s Fender Telecaster, or Paul Newman’s Rolex Daytona, are more special and shout after that any the same item, not owned by them.
- c. **Ownership:** Proof of ownership of underlying assets, potential of fractional ownership, provenance tracking of assets are some characteristics that may be highly relevant in the context of NFTs backed by real-world tangible assets.
- d. **Immutability:** This is an inherent quality of all blockchain-based tokens. The tokens as well as the information embedded on the tokens are highly resistant to tampering, absent a compromise of the underlying blockchain protocol. This results in substantial trust and transparency.
- e. **Programmability:** This is considered by many an important differentiating factor separating NFTs from real world assets. In addition to allowing artistic or business expression, NFTs can be programmed in any way that programmable software can – for example to ensure artists continue to receive residuals or moral rights throughout the lifetime of a work and not just the first sale. Moreover, experimental applications showcase how NFTs can be used as collateral for a plethora of DeFi applications, similarly to a mortgage.

NFT – A brief timeline

From breeding digital cats to programming asset ownership, the NFT space has evolved considerably from its inception. The generally recognised crypto-world antecedents to NFTs were the so-called “colored coins” on the Bitcoin network. They were first proposed in late 2012 as a way to virtually “mark” otherwise fungible bitcoins with additional code to designate them for particular purposes or use cases – thus promoting their utility while potentially reducing their fungibility.

The first widespread NFT experimentation happened on Ethereum in mid-2017 with CryptoPunks, which consisted of 10 000 unique collectible digital punks, each of which has a set of algorithmically determined characteristics. Cryptopunks were initially generated by the inventors and distributed for free. Today, given their limited supply and strong brand among the early adopter community, they are regarded as among the most significant and highly valuable NFTs. The introduction of the popular CryptoKitties in 2017 is considered by many the point at which NFTs first burst into the mainstream. CryptoKitties featured a primitive on-chain

game that allowed users to “breed” digital cats together and “produce” new cats of varying rarity. This was an important step towards allowing everyone, not just an insider or programmer, to generate an NFT. CryptoKitties became so popular that in 2018 they were responsible for the severe congestion of the Ethereum network. CryptoKitties were succeeded by a short-lived hype cycle of spin-offs.

Following this phase, other projects proceeded with less visibility, leading up to today. Currently, popular artists are experimenting with NFTs, as digital art has emerged as a natural fit for the proof of ownership, immutability and provenance tracking features of non-fungible tokens. Digital art platforms have also emerged. SuperRare, Known Origin, MakersPlace, OpenSea, Wax and Rare Art Labs all built platforms dedicated to publishing and discovering digital art or collectibles.

As the “minting” of new NFTs even for non-developers became easier, 2021 has seen a surge in interest from creators, investors, and enthusiasts. NFTs today, can be found in the sports, art and music industries with multiple use cases such as record sales, event tickets, crowdfunding for records, auctioning of collectibles.

Indicative NFT use cases

Some of the prominent use cases that have been explored thus far are as follows:

- a. **Digital art:** NFT platforms provide an avenue for artists to showcase their work, in some cases directly to the public with new or no intermediaries and lower associated costs – connecting the artist directly to the public who thereby are compensated in a fair manner by the smart contracts underlying the digital art galleries for not just the initial sale but also subsequent sales – thus making it easier to enforce moral rights that exist in some EU jurisdictions.
- b. **In-game assets:** With a market cap above 100 billion USD for the gaming industry, monetising the collectibles is certainly attractive. Major gaming houses such as EA sports, Ubisoft have already started experimenting with tokens in their platform besides provenance tracking and transaction recording on the blockchain. NFTs bring about an additional source of revenue for gamers who can buy/sell the collectibles, in-game “skins” and other assets.
- c. **Content ownership:** Videos/audio content in the art and music space have recently been auctioned out by artists via NFTs to raise funds for new albums, sell out old records, whereby the NFTs depict a fractional right of ownership of the content and any proceeds earned from the resale of underlying assets will be distributed proportionally to the NFT token holders
- d. **Tickets:** Tickets to events in the form of NFT serve as memorabilia to be part of a collection
- e. **Certificates:** NFTs are utilised for transparency, provenance tracking and to facilitate for the authenticity and verification of records.
- f. **Metaverse:** NFTs are steadily emerging as the building block for the metaverse, a future state of the internet, made up of all-encompassing virtual spaces and assets that replicates or even iterates upon the physical world.

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.

1.2 History of NFTs

New modalities of ownership and monetisation are becoming a reality as a result of NFTs, and it is reasonable to expect that their wider adoption will have substantial implications for many industries. Understanding the origin and history of NFTs might provide some indication as to how the space will evolve in the future. As we have previously established, Colored Coins are widely considered as the precursor to today's NFTs. However, they are not NFTs in the currently popular sense of a token with a complex infrastructure that can support metaversal objects, art, music, and more. Instead, Colored Coins are Bitcoins – or more likely small denominations of Bitcoin (satoshis), made unique by the fact that every extant Bitcoin can be identified and have its history tracked based on ID information built into the operation of the protocol. These markings can be used to determine their purpose, for example, to represent real-world assets on the blockchain.

On 4 December 2012, a paper "Overview of Colored Coins," was released by cryptographer and President of the Israeli Bitcoin Association, Mr. Meni Rosenfeld. In this paper, a mechanism to take advantage of Bitcoin's "fungibility" by segregating a certain number of coins from the rest for special purposes, was explained. It was mentioned that adding "specialty" to coins by segregating them from the rest could help form niche applications within the Bitcoin blockchain.

Within closed circles (also known as permissioned environments), users began adding additional data to transactions to include messages or other custom information (for example, adding third-party application IDs and hashed documents in Merkle Trees). As a result, a coin that had been customised through the addition of metadata (the rights to a physical-world asset that has been digitised and layered on top of Bitcoins on the blockchain) could be used to represent a real-world asset.

Colored Coins were envisioned to eventually replace many expensive and time-consuming financial transactions. For example, property deeds could be appended to a coloured coin, the transfer of the coin itself could then be used to represent property, or in other cases, commodities and bonds. The shortcomings of Colored Coins became quickly apparent, the value attributed to them required unanimous consensus from participants and also needed the issuer to indiscriminately redeem them for the real-world asset. If a participant decided not to accept a coin in exchange for the physical asset there is no room for recourse. On the other hand, if the system is used purely for the purposes of tracking asset transfer a simple permissioned database would serve the purpose without the need for the secure, yet inefficient infrastructure of Bitcoin.

While the significance of Colored Coins for demonstrating the potential of digital non-fungible assets on the blockchain is undeniable, strictly better solutions soon emerged. More expressive protocols facilitated complex and sophisticated implementations of non-fungibility, with public interest quickly shifting in favour of these networks.

For example, in 2014 a peer-to-peer financial platform called Counterparty was created on top of the Bitcoin blockchain. Counterparty was an economical and financial platform as well as a decentralised, open-source Internet protocol. Counterparty had a broad array of tools including wallets, an escrow agent functionality and a clearing house. Additionally, it allowed for asset creation and had a decentralised exchange, as well as a

native currency known as XCP. With this foundation, Counterparty became home to numerous projects and non-fungible assets, including a trading card game. At the same time, development had also begun on the then dormant Ethereum ecosystem. Just three months after the launch of Ethereum's mainnet the Etheria project presented users with a virtual open world composed of hexagonal tiles that can each be bought, sold and "built upon", as NFT. Counterparty and Ethereum served as an indication that NFTs were evolving past their primitive origin of Colored Coins.

The year 2017 marked a milestone in NFTs. Two "creative technologists" launched their own NFT project. John Watkinson and Matt Hall understood they could make unique characters native to the Ethereum blockchain. This also became the first major economic experiment due to the novel vector of scarcity within digital assets – the run of characters would be limited to 10 000 and no two characters would be the same. For instance, different attributes would have different levels of scarcity, and the combined attributes would define the overall rarity and appeal of the character. The project was called Cryptopunks as a reference to the early days of Bitcoin's cypherpunks, and set the foundation for what we've come to think of as NFTs today. Following the popularity of Cryptopunks, a number of other NFTs projects were created, however, the space itself didn't gain mainstream popularity until the term NFT was finally introduced with the creation of the ERC-721 token standard in the Ethereum blockchain.

The same year saw the introduction of the ERC-721, a standard dedicated to NFTs. The first project based on the ERC721 standard was CryptoKitties; a blockchain-based virtual game that featured cartoon versions of cats and allowed players to "adopt", "raise", "breed" and virtually trade them. The project was launched by a Vancouver-based company called Axiom Zen. It was during the ETH Waterloo Hackathon that the game emerged to prominence.

Cryptokitties were significant to the NFT space for three primary reasons. First, they were one of the first projects to highlight gaming as a tangible use case for blockchain, legitimising it to the eyes of many. Secondly, they underlined the significance of more flexible and expressive protocols, such as Ethereum. Their "raising" and "breeding" functions were also precursors to the widespread composability native in today's DeFi applications. Finally, Cryptokitties also highlighted the limitations of blockchain and popularised the notion of the blockchain trilemma. The project was so popular, and responsible for such a high volume of transactions, that at times rendered the Ethereum blockchain unusable. The recent rise of NFTs, as well as their adoption by other blockchain protocols, signifies a shift in market sentiment, that indicates a rising consumer preference for alternative investments.

1.3 NFT Use Cases

Gaming collectibles

Gaming collectibles is a popular sector to apply NFTs and may disrupt the gaming industry. Digital games share similarities with their physical counterparts as board games and collectibles. The main differences that have popularised them are stemming from their digitalisation. Digital games have opportunities to ignore restrictions set by the physical world. These restrictions are the degeneration of materials and the requirement for all the participants to share a common place. NFTs can enhance the digital games' characteristics and provide an opportunity to offer more.

In-game items in digital games are essentially collectibles that are valuable to players for different reasons. Acquiring items in games can be viewed as either a testament of invested resources or a display of skills. As the items may hold such intrinsic value, they carry value like collectible cards. Moreover, the digital items' perceived value may be greater than physical collectibles due to the easiness of liquidating them. Digital collectibles allow artists to experiment and express themselves in many ways resulting in more artistically creative collectibles.

Items in games have identical uses, stats and other characteristics for all the players. A unique identifier is in place to differentiate these items and is traditionally stored in a server. The blockchain allows the shift from the

server structure to decentralisation. The unique identifier is represented with NFTs and can be minted in the blockchain.

Gamers are amassing in-game items during the hours they spend playing the games. While the items are pinned to users' private accounts bestowing ownership, both items and account information is curated by the game provider. In other words, the value of the items is locked in a centralised environment. In the case of a player quitting the game, the value is locked leaving the player with no monetary benefit. Blockchain can help solve issues in ownership as its distributed ledger is used to track the ownership via the transactions.

The items tokenisation in digital games and the tracking of their ownership are paving the way to revolutionise the gaming industry. Games originally required an investment from players to acquire the means to play. Moreover, the sole reward for the players was having a good time in the game. The revolution in the gaming industry is that gamers are incentivised to play a game as they can monetarise their time by selling their tokenised items in a marketplace. Specifically, the term "play-to-earn" is popularised as it refers to a way of earning cryptocurrencies from playing video games.

Some of the most popular game implementations of NFTs are: Cryptokitties, Splinterlands, Axie Infinity, Aavegotchi and LiteBringer

Cryptokitties was developed in 2017 and was one of the first games that rose to fame. The game is backed by the Ethereum blockchain and allows players to breed digital kitties. Every digital kitty is available via the use of NFTs (ERC-721) to be traded in a marketplace. Their value was defined in the marketplace. The game had huge success to the point that 25% of Ethereum's network traffic was coming from the game's pending transactions.

Axie Infinity is a digital pet community backed by Ethereum chain and is Pokemon-inspired. Apart from the breeding pet system, the game includes a battle system along with its digital land. The pets and pieces of land are represented with the use of NFTs. In August 2021, the game achieved to have 1 million daily active players showcasing its popularity.

Aavegotchi is a game with pixelated ghosts on the Ethereum blockchain. The ERC-721 standard is implemented for token generation. The game allows the NFT staking and produces interest in aTokens used in the AAVE protocol. In this way, the game blends the DeFi and NFTs.

Splinterlands is a card gaming platform founded in 2018 that allows trading with the underlying blockchain technology. The game runs on Hive blockchain and only stores actions on the blockchain. Running a game on the blockchain may prove to be slow for the users. In July 2021, the game raised 3.6 million in dollars via private token sales.

LiteBringer is an idle RPG game that allows players to level up a character from various classes like a wizard or a warrior. The game uses the Litecoin blockchain for its implementation. The action in the game is triggering gas fees as the players' actions, like creating a character or venturing to an adventure, are transactions that are included in the blockchain.

[According to the data aggregator for the gaming industry](#), which is currently tracking 521¹ games that have issued an NFT collection, the aggregator maintains real-time data regarding the usage of the blockchain games and has an extensive categorisation according to the genre of the game.

Recently a new category of blockchain gaming segment has emerged – with the start-ups gaining fast traction. The Play-to-earn business model allows gamers ownership and value appreciation of in-game assets while playing their favourite game. By participating in the in-game economy, users are creating value

¹ As of September 24, 2021

for other users and the developers. In turn, they are rewarded with metaverse assets. These digital assets can be anything ranging from cryptocurrencies to in-game resources that are tokenised on the blockchain.

The clear advantage of the play-to-earn business model is that a gamer always creates some value that can be monetised. Even when a gamer has to pay for playing, these acquired items can always be sold again. Where mainstream games like Fortnite and League of Legends are making billions from players who spend money on digital skins that will be thrown away once players stop playing and their wallets remain empty.

NFT Art

NFTs are widely used in the digital content field. The main reason for the feasibility of NFT in digital content relates to the fragmented nature of the industry.

Digital art has evolved as the most common use cases of non-fungible tokens today. The core value proposition of crypto art derives from the value of digital authenticity and ownership. Since digital files are meant to be copied, shared and distributed, the effective digitisation of art has faced significant hurdles. Exclusivity of ownership and permanence are impossible when jpg or other digital formats are entirely fungible – each individual jpg is indistinguishable from its copies thanks to identical metadata. Now that creators can own limited editions, the question of scarcity is introduced, and with scarcity, there are broader questions surrounding value. Digital artists now can sell their art, earning a privilege that artists working with physical mediums have enjoyed for centuries. Artists who put their art on the blockchain are said to have “minted” an NFT – most commonly the ERC721 token standard. Currently, NFT platforms connect artists directly with potential buyers on each platform, liberating creatives from galleries and auction houses. A new trend has emerged with the growth of the NFT art market. Hybrid galleries showcasing nonfungible pieces of unique artwork. [According to CoinTelegraph](#) there are at least nine NFT galleries and exhibitions that have already opened this year.

NFTs of experiences of museum artifacts

The popularity and the ongoing increasing valuation of artistic NFTs have attracted museums to explore ways of introducing the use of NFTs. Museums have suffered during the pandemic, as visitors were prohibited from visiting indoor places. Auctioning NFTs in digital marketplaces has the potential to give museums access to another source of revenue. Moreover, NFTs can be accessible to the public and incentivise it in vivid interaction with the museums. The accessibility of NFTs to the public may allow museums to alleviate their dependence on donations from wealthy individuals.

The National Museum Liverpool in the UK began a project in 2017 whereby museum visitors could create NFTs about their experience of particular museum artefacts.² The project was named Crypto Connections and featured both personal and museum objects. The NFTs were created on the Ethereum blockchain, the sole option that could accommodate the creation of NFTs. This was the only option available at that time. The intention behind the project was to create a sense of collective ownership and shared guardianship in digital collections. It allows viewers of an object to have a greater understanding of the object as they can appreciate other people’s impressions and opinions of the artefact. For example, why is a jar worthy of being in a museum? If the history of the object is recorded in an NFT, and then generations of viewers and users add their experiences of that object, the NFT becomes more interesting than the actual object itself.

² National Museums Liverpool. Crypto Connections: Exploring the Personal.
<https://www.liverpoolmuseums.org.uk/collections/cryptoconnections>

A possible future use case of this kind of NFT is with statues; perhaps instead of demolishing controversial statues, an NFT could be created and attached to that statue so that its history and the context of the statue or artefact can be better appreciated by viewers and the reason for the object's controversy is more easily understood.

Another possible future use-case is the curation of digital art galleries and museums. Transporting priceless artefacts is an enormous undertaking; transporting and curating digital versions of the same priceless artefacts as NFTs allows more people to enjoy and appreciate the artefacts. In addition, the bonus of the viewer experience means that this gives the audience a much greater appreciation of the inherent value of the artefact.

Supply Chain

Supply chain and logistics are sectors that can benefit from the use of NFTs. As with every technology, NFTs will aim to address some of the challenges in the sector.

One challenge that brands face is the authenticity of products. A brand's fame is an intangible asset that carries a lot of value for all enterprises. An example comes from the winery industry, where distilleries are renowned for specific wines. Bottles can be represented as digital twins on the blockchain with the use of NFTs. Platforms of this nature are developed by the Norwegian blockchain platform **Wiv** and the **TATOO** platform by the consulting firm **EY**.

Secondary markets are accommodating transactions between individuals. Item collectors are some of the usual participants of secondary markets. In such markets, the buyer cannot easily or cheaply guarantee the authenticity of the purchased product. On the other hand, NFTs can accommodate the real-time control of authenticity and help collectors and consumers to fight against forgery. The sports firm, **Nike**, has secured a patent for the project '**Cryptokicks**' that stores the unique identifier given to each pair of shoes.

Another matter that should be taken into account in logistics has to do with the ownership of goods. Commerce is international and is carried out by numerous entities such as carriers and warehouses. The ownership tracking calls for significant effort and a lot of paperwork. As products can be replicated into digital twins on the blockchain via NFTs, the ownership can be monitored with the transaction's history that is documented on the blockchain.

The project Ownest implements NFTs in the supply chain sector in this way. Some applications generally use blockchain in place of a database to mainly store transactional data. Despite data being immutable on the blockchain, this approach can be prone to false data declaration by the stakeholders in the supply chain. As a way to mitigate the aforementioned drawback, the project implements NFTs to determine the possession of products and the consequent responsibilities. In more detail, an NFT can be regarded as the digital twin of the products and the token's owner is responsible for the physical product. The project has deployed two custom standards for tokenisation named Unitary token and Stock token⁶. The aforementioned standards draw parallels to the most notable standards on the Ethereum (ERC-721, ERC-1155).

Music Royalties

Similarly to images or video, audio attachments are supported as NFT to create a collectible piece of music. This mainly pitches in the fair distribution of royalties, while supporting novel mechanisms of music production crowdfunding. This enables blockchain-based streaming platforms to track with better accuracy the revenue generated by a particular song, while enabling a truly transparent method for artists to circulate their songs. The competitors in the music streaming industry such as Apple Music, YouTube, and Spotify might be too big to compete. Among the startups which got the most traction in the music industry is Audius, which has recently celebrated six million users.³

³ <https://www.ledgerinsights.com/music-blockchain-audius-secures-5-million-funding-from-katy-perry-little-nas-x/>

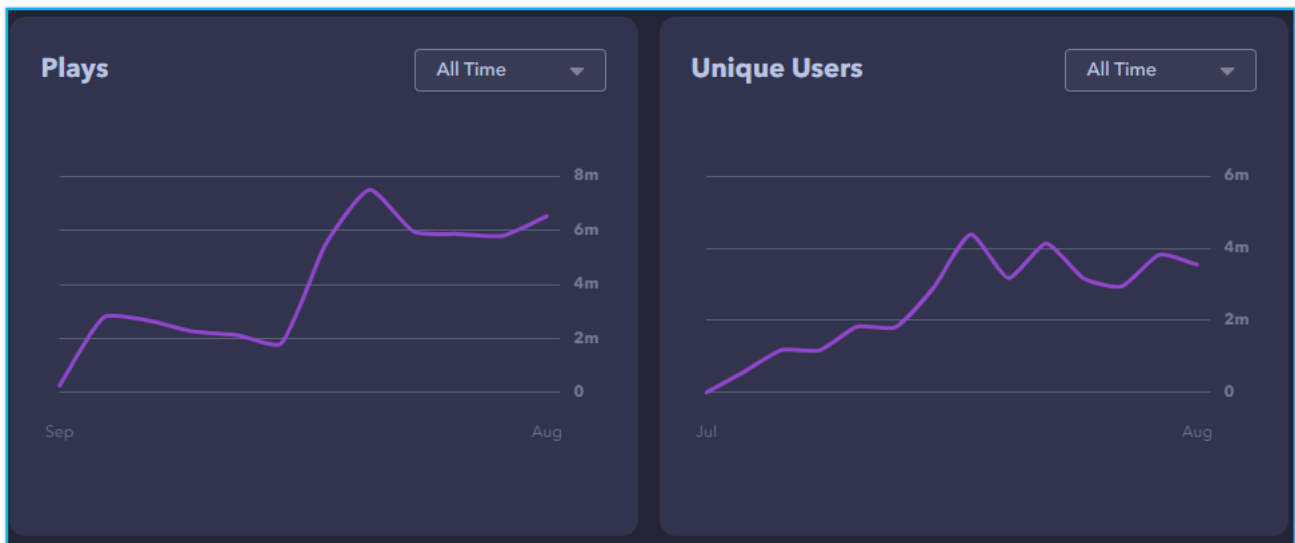


Figure 1: Number of Plays and Unique Users of Audius

Source: <https://dashboard.audius.org/#/analytics>

Authorisation (Keys/access control)

Subsequent to the authentication process, IT systems are implementing rules to control access to resources for the users. This procedure is called authorisation and evaluates the access rights of a user based on a policy. The policy is compared to the user's characteristics and a verdict is carried out that either grants or denies access. It is common to use tokens that represent the right to access resources. NFTs can fill the role of traditional tokens as a safer option. For example, OAuth2.0 is a popular standard for authentication that deploys a token in the standard. In the case of OAuth2.0, there are works like Esposito et al. and Fotiou et al. that elaborate on the concept.

Provided that NFTs have an intrinsic feature of being potentially unique, and a creator can designate an NFT's exact scarcity (1/n), this allows for an NFT to be used to access either real-world physical doors – with a wallet holding a key (NFT), or even digital (multi-sig) wallets. NFTs could be used to restrict access to anyone who does not hold one, and in this way act as a permission layer of access. Through this use case, the possibilities also extend to ticketing.

Identity

Individual identity is increasingly moving from an identity-based system to one that is reputation-based (pseudonymity). However, these individuals are still unique actors within an ecosystem of a specific vertical. An NFT could hold very specific metadata that bridges this identity onto the onchain digital world, again allowing specific permissions — only to the holder of a unique NFT, not excluding permissioned multisig capabilities made possible by NFTs.

Point system

NFTs are often provided alongside an achievement of recognition, either in-game or within a specific ecosystem. These could be team recognition NFTs, reward NFTs or proof of attendance NFTs (e.g. POAP — the Proof of Attendance Protocol which uses xDai to do exactly that). DAOs make use of these too, to mark specific wallets of users based on their activity and contribution to the DAO. This can later be used to reward or compensate the most active user wallets, based on the NFTs these hold.

1.4 The NFT Market & Marketplaces

The market demand for NFTs has spiked the interest of investors to fund new platforms, marketplaces and other NFT related venues, while entrepreneurs are now rallying to bring relevant solutions to the market. While existing available data might become available under assumptions, we will try to record the size of the industry by analysing the following key metrics: NFT Marketplaces, number of active users, number of NFTs transactions, value of NFT related transactions, funding raised by NFT-related startups, number of NFT related virtual currencies, and social media visibility and keyword traction.

In 2021, the popularity of non-fungible tokens has grown exponentially. The rapid growth and continued potential for growth are best illustrated by the size of the market, especially when considered alongside more traditional ecosystems such as the traditional art market – valued at approximately EUR 50 billion in 2020. Market capitalisation is growing year-by-year, in 2020 it reached almost EUR 297 million (a whopping 845% increase from 2018).



Figure 2: Market capitalisation of transactions globally involving a non-fungible token (2018-2020) in million EUR

Experts claim that cryptocurrency price gains during the COVID-19 pandemic are a driver behind the NFT market's growth because cryptocurrencies tend to be the denominator, or currency of exchange in digital art markets. However, some specialists believe that the NFT has value independently of market conditions. Indeed many of the most successful projects have seen price appreciation with minimal correlation to cryptocurrency prices.

The NFT market's Q1 started after EUR 90 million worth of NFTs were sold between October and December 2020. More than EUR 2 billion was spent on non-fungible tokens during the first quarter of 2021. This denotes an increase of about 2000% from Q4 2020. Sales volumes have remained high after NFTs exploded in popularity early in 2021. Monthly sales volumes on OpenSea, a major NFT marketplace, reached a record high in August 2021 approximately 3 Billion EUR on Ethereum, and approximately 50 Million EUR on Polygon.

It should be highlighted that the total NFT sales for 2021 (currently from November 15th, 2020 to November 15th 2021) amount to more than EUR 8.97 Billion. While the overall NFT sales in 2021 are enjoying a significant spike, not all sectors have accrued value at the same rate. One of the key characteristics of this success is the Axie Infinity game (Published by Sky Mavis) and affiliated AXS currency have been driven to dramatic heights. Though the game has secured upwards of EUR 460 million since July 2021, the success of Axie is dwarfed by video games and franchises from the traditional sector such as Pokemon and Super Mario which are orders of magnitude larger at revenues of EUR 85 billion and EUR 30 billion respectively.

At the beginning of October 2021, 70 artists sold several editions of a series of digital artwork known as Hashmasks for more than EUR 8 million. Hashmasks are a partially randomised artwork project built on the Ethereum network.

As payment giants and large technology companies enter this field, more and more fields will unlock new opportunities and revenue streams.

According to Non-fungible Tokens Quarterly Report Q2 2021, Collectibles were responsible for 66 % of all the volume traded during this quarter.

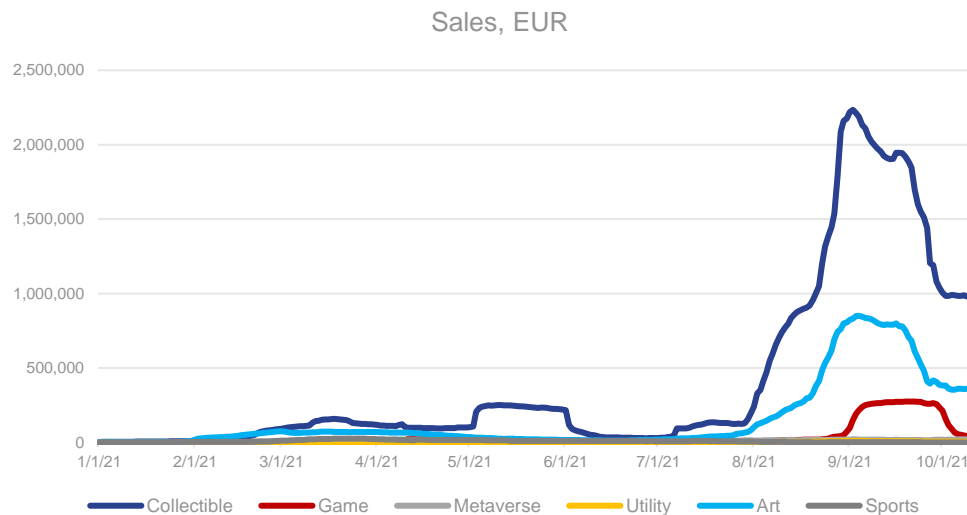


Figure 3: Sales volume (monthly)

The same trends are displayed for the sales numbers. The largest number of sales were made in the Collectibles segment (more than EUR 32.5 million in 2021 and EUR 31 million in 2020). The second and third largest categories are Sport and Art NFTs with EUR 11.3 million and EUR 13 million, respectively. It should be noted that the total number of Sport and Art NFTs sales from January to October 2021 has already exceeded by 300 % the number of sales for the entire 12 months of 2020.

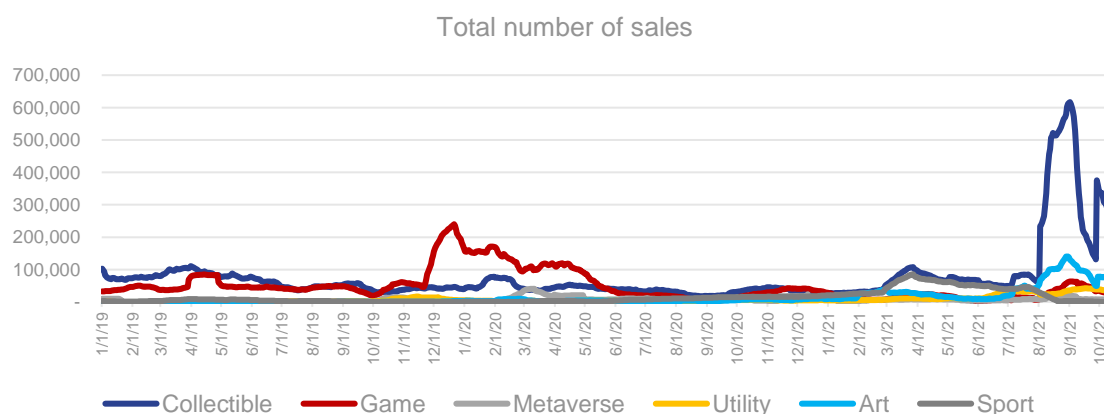


Figure 4: Total number of sales (monthly)

Based on the figures below, the Collectibles segment is the largest part of total sales in the period of January 2021 to October 2021 and it equals to 52.1 %. Art and Sport NFTs are second and third respectively with

15.2 % and 14.9 %. As of April 2021, roughly 23 700 NFTs were sold in the art segment during the previous 30 days. As of September 2021, the aggregated number of sales over 30 days reached approximately 94 500. Finally, Metaverses have the smallest share in total sales – though many of the largest projects are anticipated to take place in this all-encompassing digital re-creation of reality.

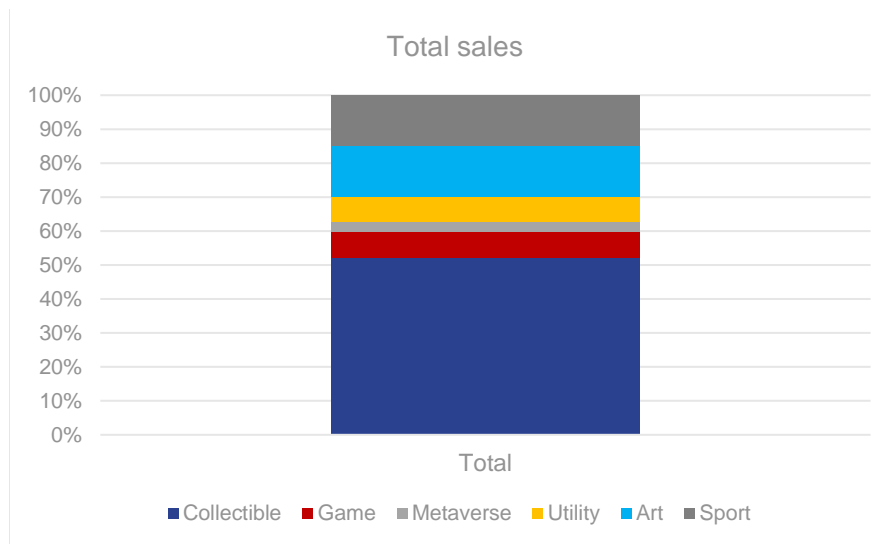


Figure 5: Shares of total sales (from January to October 2021)

Proponents of the technology believe that NFTs are a general trend in human technology, and anything can be implemented in almost any sector for any purpose that requires scarcity and non-fungibility. Opponents believe that the NFT market is full of speculation and bubbles, and most NFT products are similar phenomena to the Tulip bubble, where there is no intrinsic value behind the capital inflow. However, the number of supporters seems to be growing more quickly than detractors. The number of active market wallets is also increasing. During this quarter a new record was set in the number of active wallets (> 175 000) with both the number of buyers and sellers increasing.

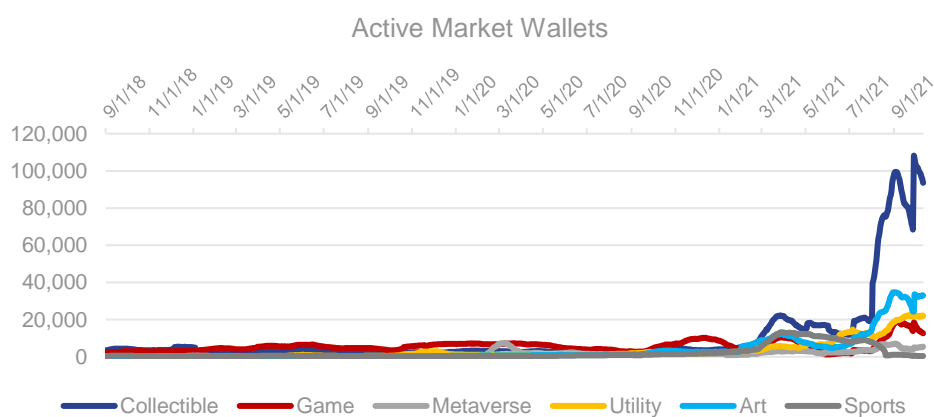


Figure 6: Active market wallets number

Figures in this section should be considered as approximations. According to the evaluation of data sources and due diligence of our desk research team, we trust that the shared data present an accurate landscape monitoring of the NFT industry.

All data are tracked as of 15 November, 2021:

NFT MARKETPLACES

Based on the data metrics platform dapp.com, we are able to identify 229 decentralised applications which have been identified as NFT Marketplaces. It has been outside of the scope to evaluate if all the listed applications were relevant to our research terms. By ranking the DApps based on their on-chain performance, we were able to conclude that less than 20 marketplaces had daily active “users” that exceed at least 100 unique wallet addresses that have triggered the on-chain smart contract function of a DApp within 24 hours. Similarly, only 44 marketplaces had a trading volume worth more than USD 100 daily – the total value of tokens spent to trigger the on-chain smart contract function. Dapp.com reports a total number of 309 900 monthly users for August 2021, increased almost by 150 % in comparison to July 2021. The total transaction volume for the reference period is USD 3.18 billion, increased by 333 % in comparison to July 2021.

DappRadar.com lists only 34 NFT marketplaces, with only 20 out of those having on-chain volume and users. StateoftheDapps.com lists 107 NFT related DApps, though the directory does not provide on-chain metric references.

Despite the growing number of new players, the volume and users are highly concentrated within the Top 10 most popular NFT related marketplaces.

NFT NUMBER OF UNIQUE USERS

Blockchain technology helps us to track with great accuracy metrics such as the metrics and traction related to NFT-related transactions. Potentially inaccuracy might be possible only by not identifying a smart contract related to an NFT collection, hence it will not be tracked as a user.

NonFungible.com maintains one of the most extensive data depositories with on-chain metrics for NFT collections, though it is currently not monitoring all Layer 1 and Layer 2 blockchains, which leads to untracked data for popular NFT related DApps.

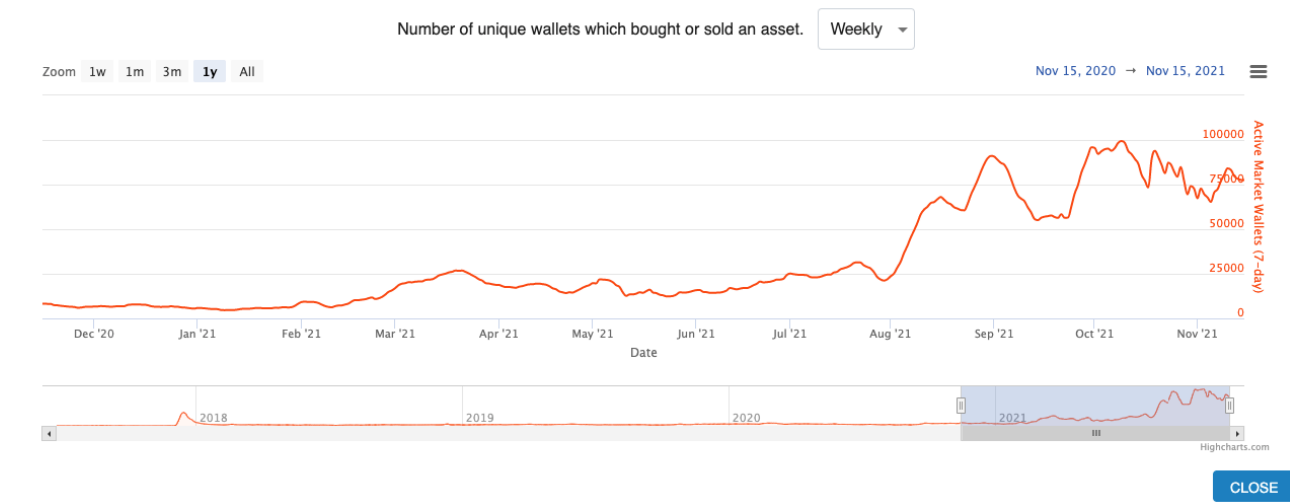


Figure 7: Number of Unique Wallets which bought or sold an asset

October 2021 remains the peak of unique wallets which bought or sold an NFT asset, with the active monthly market wallets (30-days) approaching 100,000. The chart above clearly shows a spike in interest during the period August-October 2021.

NFT NUMBER OF TRANSACTIONS

While the number of transactions alone might not be enough to signal the growth of the NFT industry, it is worth understanding the number of sales made during the examined period, and then comparing with other data such as primary offering and secondary traders to better understand the demographics of the NFT collectors.

The number of 30-day transaction by the first week of September 2021 (peak) approaches 135,000 unique transactions.

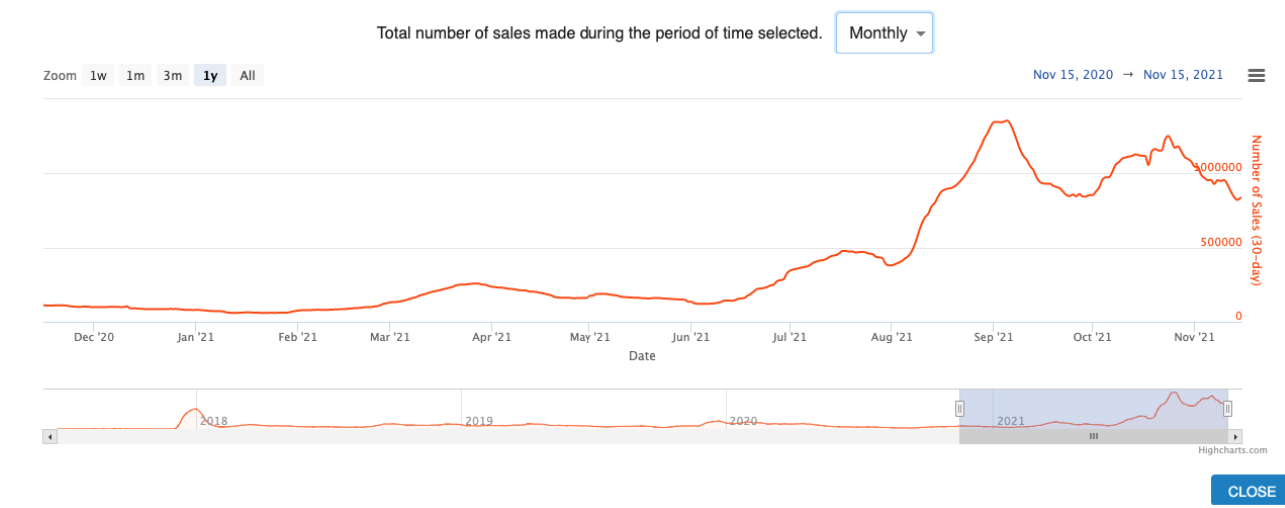


Figure 8: Total Number of NFT sales- reported monthly

Approximately 650,000 transactions as of early September 2021 are offered for the first time known as “primary-market” sales.

An equivalent number of transactions are identified as secondary market transactions, referring to existing NFTs which are now sold for at least a second time in the NFT marketplaces.

This suggests the industry is currently approaching a great number of new creators who are experimenting, and they are offering their NFTs for first time through primary issuances.

NFT VALUE OF TRANSACTIONS

The value of NFT-related transactions is one of the most important metrics for those interested in evaluating the prospects of the NFT landscape. The 30 days sales has approached almost USD 900 million across monitored NFT collections tracked by nonfungible.com as of 28 August 2021.

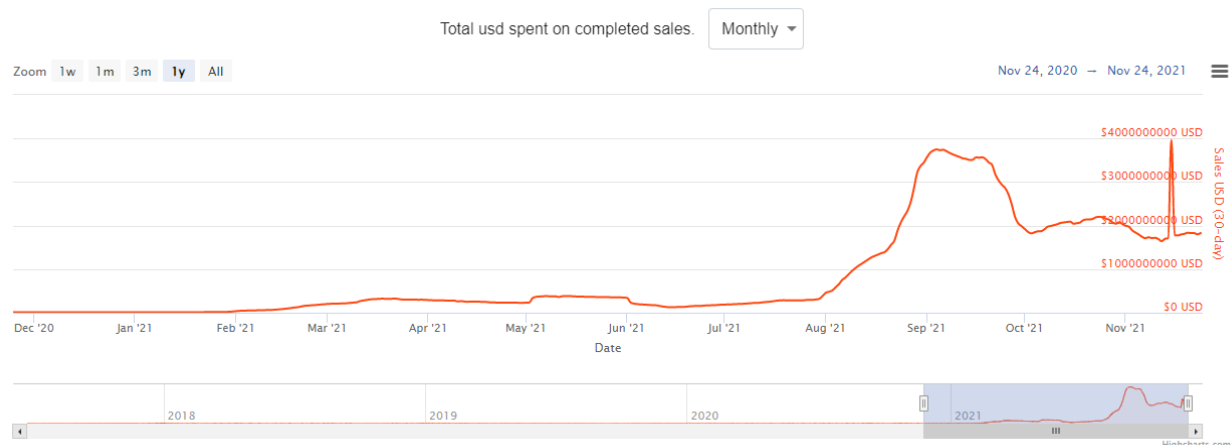


Figure 9: Total Number of NFT sales- reported monthly

NFT FUNDING

Notable funding rounds for NFT related startups have spiked during 2021. Currently, there are no available data for the total funding raised by NFT startups in the reference period, though we have collected the most notable funding rounds in the examined period January-August 2021.

Startups	Latest Funding	Series	Last Updated
MakersPlace	\$30 Million	Series A	August 2021
AlchemyNFT	\$6 Million	Angel & Seed Rounds	July 2021
Open Sea	\$100 Million	Series B	July 2021
Splinterlands	\$3.6 Million	Private Sale	July 2021
ZED RUN	\$20 Million	Series A	July 2021
Showtime	\$7.6 Million	Seed Round	July 2021
Nifty	\$10 Million	Seed Round	July 2021
Animoca Brands	\$139 Million	Unicorn Capital Raise	July 2021
Mintable	\$13 Million	Series A	July 2021
Rarible	\$14.2 Million	Series A	June 2021
Snickerdoodle Labs	\$2.3 Million	Seed	June 2021
RTFKT	\$8 Million	Seed	May 2021

Startups	Latest Funding	Series	Last Updated
Burnt Finance	\$3 Million	Seed	May 2021
360X	€ 10 Million	Seed	April 2021
Efinity	\$18.9 Million	Seed	March 2021
SuperRare	\$9 Million	Series A	March 2021
Dapper Labs	\$305 Million	-	March 2021
OpenSea	\$23 Million	Series A	March 2021
Rarible	\$1.75 Million	Seed	February 2021
Async Art	\$2 Million	Seed	February 2021
Sorare	\$50 Million	Series A	February 2021

Table 1: Notable Funding Rounds as collected by the EUBOF team

NFT RELATED VIRTUAL CURRENCIES

Data aggregator CoinMarketCap categorises 420 virtual currencies related to NFT protocols and tokens out of the 14198 cryptocurrencies tracked by the data provider. The aggregated market capitalisation of the tracked cryptocurrencies is approximately EUR 57 billion as of 15 November 2021. Those tokens are unrelated to the NFTs themselves, and only refer to cryptocurrencies issued by the protocols, and act as utility, governance or other types of token.

For the same reference period, CoinGecko reports a capitalisation of EUR 54 billion for Non-Fungible related tokens.

NFT GOOGLE SEARCH VOLUME

The Google search volume for the acronym NFT has reached an all-time high during 2021. Search volumes are relative between 0 to 100, with 100 being the maximum value from a defined time period. The spike in interest for NFTs during 2021 is visible, especially during the first few months of the year. The trend keeps stronger during October and November 2021, showcasing potentially a new audience which has acquired interest about NFTs.

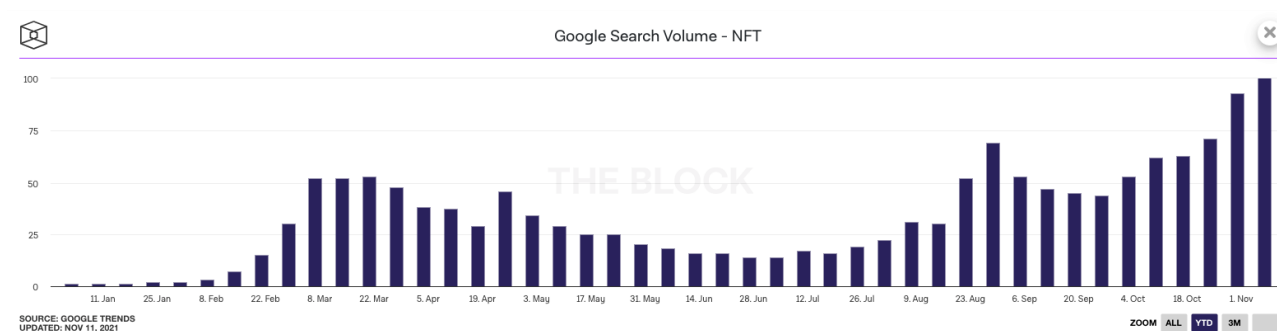


Figure 10: Google Search volume for the term NFT

Source : <https://www.theblockcrypto.com/data/alternative-crypto-metrics/web-traffic/google-search-volume-nft>

NFT Collections

According to the NFT data provider CryptoSlam.io, important analytics and insights were gathered by monitoring the TOP 15 NFT collections as of 15 November 2021.

⚡ NFT Collection Rankings by Sales Volume (All-time) ⓘ


	Collection		Sales		Buyers	Txns	Owners
1	 Axie Infinity		\$3,164,609,456		1,022,860	9,200,930	2,552,002
2	 CryptoPunks		\$1,633,299,428		4,691	18,896	3,278
3	 Art Blocks		\$1,060,611,541		20,322	114,919	23,968
4	 NBA Top Shot		\$775,794,164		372,269	11,496,819	600,686
5	 Bored Ape Yacht Club		\$705,774,249		8,111	22,262	5,814
6	 Mutant Ape Yacht Club		\$376,935,046		9,648	16,110	10,025
7	 Loot		\$263,817,019		3,553	9,943	2,558
8	 Meebits		\$233,706,114		5,030	13,394	5,340
9	 Cool Cats		\$178,638,272		7,868	22,808	4,998
10	 CrypToadz		\$164,868,914		6,174	14,786	3,507
11	 Parallel Alpha		\$159,030,475		10,649	64,926	
12	 MekaVerse		\$155,808,692		4,586	9,135	5,112
13	 0N1 Force		\$146,502,888		6,850	15,866	4,232
14	 Pudgy Penguins		\$134,702,285		9,842	26,507	4,730
15	 PUNKS Comic		\$127,963,584		3,321	8,663	3,101

Figure 11: NFT Collectible Rankings by Sales Volume

Source : <https://cryptoslam.io>

Axie Infinity, a blockchain metaverse game that has seen unparalleled growth, tops the list. The game is built on Ronin, an Ethereum sidechain that allows transactions with almost non-existent gas fees. Axies has evolved into one of the most valuable NFT collections with USD 1.7 billion in total sales. Almost half of sales, approximately 45 % were made in August 2021. The Axie Infinity DAO generated USD 355 million in revenues and USD 765 million in sales volumes. The game has reached a total amount of more than 800 000 discord members and 467 000 Twitter followers which are indicative metrics measuring its unparalleled growth. Finally, Axie Infinity has almost reached the top 50 most popular games on the Twitch streaming platform.

Chapter 2: The Technology behind NFTs

2.1 Exploring the NFT Tech Stack

Layer 1

Between 2016 and 2018, new blockchain platforms started to appear at a rate similar to a Cambrian explosion – mainly due to the excess capital availability to finance core blockchain infrastructures. All of the platforms supporting Turing complete programming language are capable of supporting NFT tokens. Despite the widespread support of the NFT token standards, the development activity around NFT standards is concentrated on several factors. On the one hand, blockchain platforms like this did not really reach the critical mass of adoption, neither generally, nor in terms of tokenisation. As such, they serve pretty much for niche applications. On the other hand, NFT itself needs to have a vibrant and living ecosystem of developers, IT professionals and entrepreneurs that appear only on certain platforms.

From a practical point of view, the following properties are to be considered at Layer 1 infrastructure for NFT applications.

- General platform characteristics are best to be captured within the blockchain trilemma (Figure X). A Blockchain platform can manage two of the following three characteristics: Security, Decentralisation and Scalability (also covering performance attributes). Practically, existing Layer 1 technologies are somewhere between the almost centralised and performant, and the totally decentralised but “slow” categories. It is important to note that none of these platforms is wrong from an NFT point of view. Secure and decentralised approaches can be used for high-value tokenisation, such as property NFTs as low-security ones can rather be used in low-value use-cases like in gift card tokenisation.

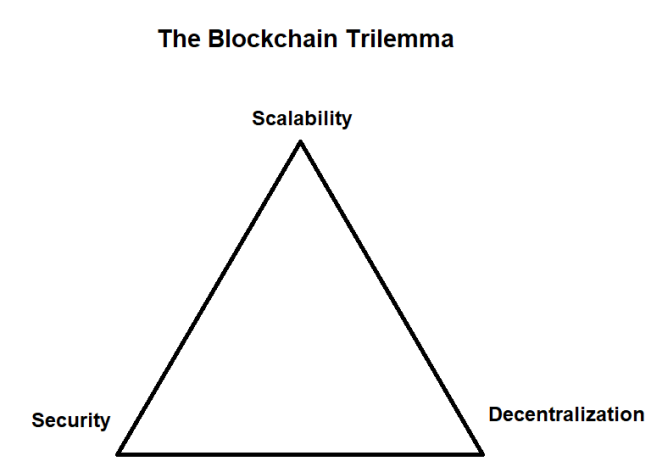


Figure 12: Blockchain trilemma

source : <http://www.returnvalues.academy/blockchain/basic/trilemma/>

- Transaction fee dynamics may be considered as one of the platform characteristics. However, due to its importance, it might be a good idea to consider these separately. Some platforms like the Ethereum mainnet have a high transaction fee that makes it impossible to realise low value or often high-volume transacting token use-cases.

- Interoperability is one of the non-technical, but important features. It describes how much a solution on this platform is capable of cooperating with other smart contracts, other blockchain platforms, wallets, custodial or non-custodial asset solutions. Interoperability is easier if there are well-established token standards on the field.
- Size of the network effects is important as well, including how many competencies, opensource tools, developers and knowledge sharing events set focus on the given platform. Experience shows that platforms with shrinking or minimal communities will become extinct in the long run.

It is not within the scope of this report to evaluate the differentiation between Layer 1 protocols, though an extensive reference to the Token Standards supported by each protocol is available in the Session 2.2 NFT Token Standards. With the current available metrics, the NFT activity is concentrated within the Ethereum, Binance Smart Chain, Solana, Flow, Algorand, Tezos and Wax blockchains. Other protocols are continuing to expand their NFT focused infrastructure. Among the Layer 1 NFT-related initiatives is the Efinity blockchain, which is developed by Enjin. Efinity is a next-generation blockchain, purpose-built blockchain for NFTs. Fees on Efinity are designed to stay in the background. End-users don't even need a blockchain wallet. Transactions are confirmed in six seconds, which permits the fast response times needed for mainstream applications. Finally, one of the leading gaming studios Dapper Labs which is known for projects such as CryptoKitties, has opted to build a new blockchain protocol named Flow. This is a fast, decentralised and developer-friendly blockchain. In fact, Flow has been designed as the foundation for a new generation of games, apps and the digital assets that power them.

Layer 2 Sidechains and other Scalability Protocols

The transaction volume, in combination with the fees, in the Ethereum blockchain has led many NFT-related projects to migrate to Layer 2, sidechains and other scalability protocols.

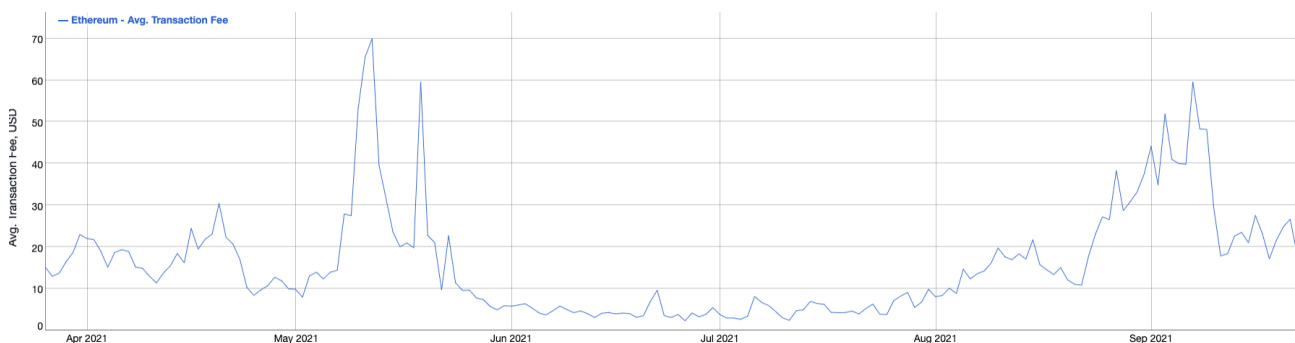


Figure 13: Average Ethereum Transaction Fees between April – September 2021

Source: <https://bitinfocharts.com/>

While we don't have applicable data to refer to the exact traction of NFT-related DApps or Marketplaces across the Layer 2 solution, [the analytics and research website about Layer 2 Scaling](#) is showcasing the overall traction of Layer 2 protocols.


















No.	Name	Value Locked	7 days change	Market share	Purpose	Technology
1.	 Arbitrum	\$2.4B	-6.78%	71.74%	Universal	Optimistic Rollup
2.	 dYdX	\$418.1M	+18.03%	12.74%	Exchange	ZK Rollup
3.	 Optimism	\$217.1M	-8.41%	6.61%	Universal	Optimistic Rollup
4.	 Loopring	\$113.7M	-19.26%	3.46%	Payments, Exchange	ZK Rollup
5.	 ZKSwap V2	\$70.3M	-12.32%	2.14%	Payments, Exchange	ZK Rollup
6.	 DeversiFi	\$62.8M	+40.94%	1.91%	Exchange	Validium
7.	 zkSync	\$13.8M	-6.98%	0.42%	Payments	ZK Rollup
8.	 Sorare	\$11.9M	-9.30%	0.36%	NFT, Exchange	Validium
9.	 ZKSwap	\$6.1M	-39.58%	0.19%	Payments, Exchange	ZK Rollup
10.	 Habitat	\$3.8M	+28.77%	0.12%	DAO, Treasury	Optimistic Rollup
11.	 ImmutableX	\$3.7M	-1.62%	0.11%	NFT, Exchange	Validium
12.	 OMG Network	\$3.1M	-0.26%	0.09%	Payments	Plasma
13.	 Aztec	\$1.4M	+11.85%	0.04%	Private payments	ZK Rollup
14.	 LeverJ	\$1.3M	-11.96%	0.04%	Exchange	Plasma
15.	 Polygon Hermez	\$302.6K	-6.41%	0.01%	Payments	ZK Rollup
16.	 Layer2.Finance	\$263.4K	+3.99%	0.01%	DeFi aggregation	Optimistic Rollup
17.	 Fuel	\$6.9	+0.00%	0.00%	Payments	Optimistic Rollup

Figure 14: Ranking of Layer 2 Protocols according to Market Share, September 2021

Source: <https://l2beat.com/>

As shown in Figure 12, it is only Immutable X and Sorare that are tagged with having NFT as their core purpose. Polygon is currently not tracked by this particular research portal since it is categorised by the author as a proof of stake sidechain.

Polygon, an Ethereum Layer 2 protocol, has proved very resilient towards approaching NFT creators, and currently counts more than 100 NFT and gaming projects as listed [in the Polygon ecosystem directory](#).

The transaction volume, in combination with the fees, in the Ethereum blockchain has led many NFT-related projects to migrate to Layer 2 sidechains and other scalability protocols. One of the most popular blockchain games, Axie Infinity, has developed its own Ethereum sidechain, Ronin, which has proved effective to handle the influx of users and traction the game has, while keeping the fees to the lowest possible.

In a similar direction, the developers of Gods Unchained led the development of a new Ethereum Layer 2 scaling solution which is known as Immutable X. This uses ZK-rollups powered by StarkWare. Immutable X is promising zero gas fees, instant trades for games, NFT applications and NFT marketplaces positioning as an NFT-focused Layer 2 on Ethereum.

Similarly, [Loopring zkRollup has extended support for NFT](#) minting, trading, and transfers directly on Layer 2. Any NFT minted on Layer 2 can be withdrawn to Layer 1, supporting both ERC1155 and ERC721.

2.2 NFT Token Standards

Smart contract standards describe rules which are applicable to the smart contract logic. The standards are application-level for blockchains which are supporting smart contracts. Smart contract standards can include token standards, name registries, library/package formats and more.

The smart contracts must follow the requirements in order to support and perform actions, like the creation of tokens, performing transactions, spending and so on. Smart contract standards are important because they define the rules of utilising the blockchain network and constitute communication among different smart contracts efficiently.

For blockchains that support smart contracts, token standards are often included to tell people how to create, issue and deploy new tokens. In principle, there are three major types of tokens [Figure Z]⁴:

1. **Fungible** tokens are like coins of a currency where each piece is interchangeable with one another, having the same meaning and value. ERC-20 is the most well-known standard for fungible tokens⁵.
2. **Non-fungible** tokens are like individual pieces of art. Each piece is distinguishable and might be totally different from every other piece. ERC-721 is the most well-known standard for fungible tokens⁶.
3. **Hybrid tokens** combine the characteristics of fungible and non-fungible tokens, having classes of tokens where each token is interchangeable but only within the class. Tokens among classes cannot be exchanged with one another. A typical example is a role-playing game, where swords and shields can be represented as two separate token categories. As shields and swords are indistinguishable within their categories, a sword cannot be automatically exchanged for a shield. ERC-1155 is the most well-known standard for hybrid tokens.⁷



Figure 15: Token types

source: <https://opensea.io/blog/guides/non-fungible-tokens/>

Initially, the non-fungible token standard was built on Ethereum, the most widely used blockchain protocol and pioneer in the NFT space. Below we present the most widely used NFT token standards, across different blockchains which are widely accepted. We will not refer to token standards that are mimetic to Ethereum token standards and have later been adopted by other blockchain protocols.

Ethereum Blockchain

ERC 721 Standard

The ERC-721 token standard is the basic and most common NFT standard, describing tokens each having individual characteristics. The ERC-721 standard is basically an interface description in Ethereum, Solidity (more precisely a set of compulsory and optional interfaces, table X). While specifying the functionalities to

⁴ NFT Bible, <https://opensea.io/blog/guides/non-fungible-tokens/>

⁵ ERC-20 token standard, <https://eips.ethereum.org/EIPS/eip-20>

⁶ ERC-721 token standard, <https://eips.ethereum.org/EIPS/eip-721>

⁷ ERC-1155 token standard, <https://eips.ethereum.org/EIPS/eip-1155>

be implemented, the interfaces do not specify how these functionalities should be implemented. This leaves a lot of free space for different implementations and different business logic. The following categories of functionality are important:

- **Basic token functionalities** focus on transferring a token from one owner to another one. Owners in the Ethereum compatible world may include people (externally owned accounts) or smart contracts, meaning more cryptographic ownership and not necessarily a legal one. In addition to simple transfer functionalities like transferring the token from one owner to another, extended three-party ownership is available. In such cases, one party can give allowance to a third party to make a transfer on its behalf. It is commonly used by exchanges or non-custodian services.
- **Token information** functionalities focuses on getting different kinds of information from the token itself. There are two categories of information. On the one hand, there are calls for querying the owner of a token, the number of tokens of an owner, allowed tokens to be transferred, total supply of tokens and so on. On the other hand, every NFT token contains metadata information. Metadata connects the blockchain token with non-blockchain digital or even real-world entities. Metadata is represented as a URI linking a complex JSON file that describes in detail the type of entity and how it is represented by the NFT token. The JSON file itself is not stored in the blockchain. Instead, it is stored on a centralised or decentralised storage, like on IPFS.

Function	Description	Interface
<i>balanceOf</i>	Number of tokens for an owner	ERC-721
<i>ownerOf</i>	Owner of a given NFT	ERC-721
<i>safeTransferFrom</i>	Transfer token from one owner to another	ERC-721
<i>transferFrom</i>	Non-safe implementation of transfer	ERC-721
<i>approve</i>	Approve asset transfer for third-parties	ERC-721
<i>setApprovalForAll</i>	Approve asset transfer of all third-parties	ERC-721
<i>getApproved</i>	Get approved address for a token	ERC-721
<i>isApprovedForAll</i>	Query if address is approved for transferring from another address	ERC-721
<i>supportsInterface</i>	Check if the contract supports a function	ERC-165
<i>onERC721Received</i>	Implement if the contract is able to receive erc721 tokens	ERC721TokenReceiver
<i>name</i>	Name of the token	ERC721Metadata
<i>symbol</i>	Symbol of the token	ERC721Metadata
<i>tokenURI</i>	URI for the metadata json	ERC721Metadata
<i>totalSupply</i>	Total amount of NFT tokens	ERC721Enumerable
<i>tokenByIndex</i>	Get token by index	ERC721Enumerable
<i>tokenOfOwnerByIndex</i>	Get token by index and owner	ERC721Enumerable

Table 2: ERC-721 functions

source: <https://eips.ethereum.org/EIPS/eip-721>

Apart from the previously mentioned functionality, an ERC-721 might implement some useful further services that are not part of the standard, but required for real-life applications. Such services are, for example:

- The creation or destruction of tokens is important for most of the use cases. The implementation might strongly vary from application to application, but usually, kind of a *mint* and *burn* functionalities are implemented.
- Token security is a crucial part of every token implementation. It does not only contain the secure implementation of the previously mentioned services, but additional functions might also be required, like pausing or securely upgrading a contract.
- Token governance can usually be a complex element of a token. It implements business logic in terms of who is allowed to do anything with the token, like burning or minting tokens, and if there is a consensus mechanism before such a service call.

ERC-1155 Standard

ERC-1155 standard extends the functionality and business logic in a sense that not only individual distinguishable tokens are implemented but sets of tokens as well. The ERC-1155 is a standard that was created in 2018 and it is universal. In other words, deployments can facilitate any combination of tokens such as fungible, semi-fungible or non-fungible tokens. Furthermore, the standard is able to mint existing tokens to new ones for further uses. The blockchain company, Enjin, deployed ERC-1155 with the intent to be used mainly in games.

The ERC-1155 differs from pre-existing token standards like ERC-20 and ERC-721 as it aims to tackle some of the issues in those standards. In conjunction with ERC-20, ERC-1155 does not require a separate smart contract deployment for each token. Furthermore, the new standard differs from the ERC-721 in handling transactions. The different way of handling transactions consequently results in reducing gas fees. ERC-1155 permits the batch transfer of token IDs and values without the need for a wrapper contract. The batch transfer conserves computational requirements and reduces gas fees. While being more energy-efficient, the ERC-1155 standard has a drawback in comparison to the ERC-720. This drawback has to do with tracking ownership which is harder to take place in the standard.

In an ERC-721 token, different NFT tokens are represented by simple numbers that relate to some information outside the blockchain with the help of the metadata URI and JSON file. At ERC-1155 from each individual token there can be many pieces that cannot be distinguished from each other in the given category (see Figure K, where each token ID, there is a group of tokens with a different colour).

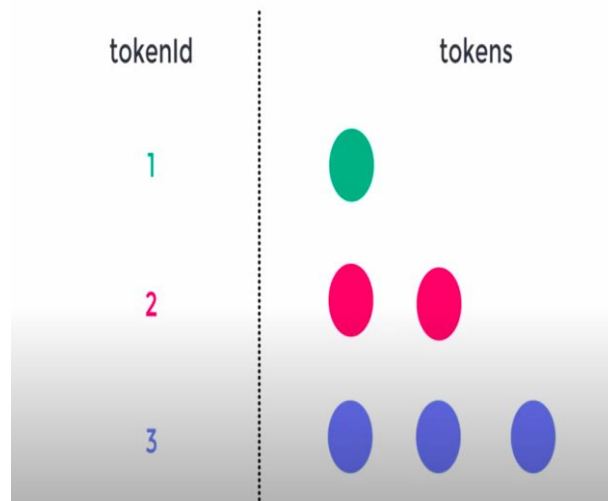


Figure 16: Token IDs and token groups at ERC-1155

source: <https://opensea.io/blog/guides/non-fungible-tokens/>

The ERC-1155 functionalities are usually extended with a parameter “value”. This means that functionalities like transfer, transferFrom, approve are not only applied to one piece of token identified by the token, but to a set of tokens in a given token category. What’s more, ERC-1155 implements batch services to realise several operations to different sets and categories of tokens.

DRAFT NFT Standards

Other token standards are rather technical extensions of basic NFT tokens. Many other innovative token standards have been proposed and are awaiting for approval by Ethereum’s governing committee. There are currently at least seven draft Ethereum Improvement Proposals, which are in draft mode and waiting for approval. Several are presented below.

ERC 988 Standard

In addition to the previously described two standard Ethereum tokens, there is an active ongoing investigation both within and outside of the open source Ethereum developer community with a couple of exciting examples. Ethereum governance happens off-chain with a wide variety of stakeholders involved in the process. Among the involved stakeholders are Ether holders, application users, developers, node operators, EIP Authors, Miners/Validators, and Core Protocol developers. To learn more about the Ethereum governance framework, you can refer to the formal process for introducing changes to the Ethereum protocol.

One interesting approach is the ERC-998 standard that realises composable non-fungible tokens⁸. In a composable token, a token can also contain further NFT tokens that will eventually be traded as a bundle. The ERC-998 standard is an extension to the ERC-721 as it enhances the standard to bundle tokens created with ERC-20 standard (fungible) and ERC-721 (non-fungible). Essentially, a list or a tree of tokens composes a new token and the underlying assets are connected by ownership.

⁸ ERC-998 token standard, <https://github.com/ethereum/eips/issues/998>

One example for composable token standards is again related to gaming. As in the case of role-playing games, a non-tangible token might represent an in-game character having all the belongings (shields or swords) of the character as further NFT tokens.

This standard suggests two different types of composable events that are foreseeable yet unintended. Composable are tokens that can either own or be owned by other tokens. The top-down approach holds information about its underlying tokens (child). Essentially, an ERC-721 token is created and used as a container for individual tokens. Ownership of the parent ERC-721 can result in exchanging the underlying tokens. On the other hand, the bottom-up tracks information about parent tokens and permits ERC-721 tokens to attach to other ERC-721 tokens. The created composable ERC-721 token tracks the owning address of a token and the parent token's ID. In this type of composable, multiple tokens are attaching themselves to a parent ERC-721 token. The parent token can be used in transactions to transfer the ownership of the attached tokens. The types to choose are dependent on the use. While top-down composable can resolve the need for transferring regular ERC-721 tokens to non-fungible tokens calls, bottom-up composable addresses the opposite relation.

This standard tries to foresee issues that may come up during the operations by deploying the explicit transfer parameter. The parameter calls for the definitions of owners for an exchange to happen. In other words, the "from" and "to" must be explicitly provided to avoid unintended events. A composable contract between three users is an example of unintended events, as the final user can find himself holding two tokens instead of one. These are the following:

Other Draft Ethereum NFT Standard

- The ERC-2309 standard Consecutive Transfer Extension aims to solve the scalability issues of ERC-721 in the NFT creation. This standard can cover the processes of minting, burning and transferring in a batch of tokens. Time complexity in the ERC-721 that requires minting each token separately in a defined procedure, results in an $O(n)$ complexity. In contrast, the ERC-2309 standard requires stable time in the creation of any number of tokens, which translates as an $O(1)$ time complexity. It should be noted that the tokens in ERC-2309 should have consecutive token identifiers in order for a batch of tokens to be created. The standard has the same goal as the ERC-1155, but it differs in the ability to mint massive amounts of tokens in an efficient way. There are cases in the ERC-1155 standard that results in prohibitive gas fees or runs out of gas.
- EIP-2615: Non-Fungible Token with mortgage and rental functions This is an extension to ERC721 Non-Fungible Tokens to support rental and mortgage functions. These functions are necessary for NFTs to emulate real property, just like those in the real world.
- EIP-1948: Non-fungible Data Token Some NFT use-cases require dynamic data associated with a non-fungible token that can change during its lifetime. Examples of dynamic data include intellectual property tokens that encode rights holders and tokens that store data to transport them across chains. The existing metadata standard does not suffice since data can only be set at minting time and not modified later. The proposal is made to standardise tokens with dynamic data.
- EIP-1523: Standard for Insurance Policies as ERC-721 Non Fungible Tokens This suggests a standard interface for insurance policies based on ERC 721. The standard allows for the implementation of a standard API for insurance policies within smart contracts.
- EIP-2981 NFT Royalty Standard This introduces a standardised way to retrieve royalty payment information for non-fungible tokens (NFTs) to enable universal support for royalty payments across all NFT marketplaces and ecosystem participants.
- EIP-3569: Sealed NFT Metadata Standard This provides a mechanism to immortalise NFT metadata in a cost-effective manner.

- EIP-3589: Assemble assets into NFTs This defines an ERC-721 token called assembly token which can represent a combination of assets.

NFT Token Standards across other blockchains

There is ongoing research outside the Ethereum community, either to adapt existing NFT standards or define new solutions. These initiatives have some conceptual similarities to the previously mentioned example, but they usually have different functionalities or interfaces.

Flow Blockchain

Smart contracts on the Flow network are written in Cadence programming language. Flow allows for “Upgradeable Smart Contracts” such as smart contracts that can be deployed in a ‘beta state’ and then be incrementally updated by the original authors until they are satisfied.

The Flow Non-Fungible Token standard supports these features and covers much of the same ground that ERC-721 or ERC-1155 cover, but without most of the downsides as argued by the Flow developer community.

- Tokens cannot be sent to contracts that do not understand how to use them.
- If the recipient is a contract that has a stored Collection, the tokens may be deposited to that Collection without a clunky approval process.
- Events are defined in the contract for withdrawing and depositing. As such, a recipient will always be notified that someone has sent them tokens with their own deposit event.
- This version can support batch transfers of NFTs. Even though it isn't explicitly defined in the contract, a batch transfer can be undertaken within a transaction by just withdrawing all the tokens to transfer, then depositing them wherever they need to be, automatically.
- Transfers can trigger actions because users can define custom Receivers to execute certain code when a token is sent.
- Easy ownership indexing: Instead of having to iterate through all tokens to find which ones you own, you have them all stored in your account's collection. This way you can get a list of the ones you own instantly.

The NFT Storefront is among the token contracts supported by the Flow Blockchain. It is a general-purpose Cadence contract for trading NFTs on Flow. NFT Storefront is implementing a marketplace that can take any currency in order to vend any token in a safe and secure way. This means that only one instance of the contract is needed, and its resources, transactions and scripts can be used by any account to create any marketplace.

EOSIO Blockchain

EOSIO blockchain is featuring four different Non-Fungible Token (NFT) Standards:

Atomic Assets: AtomicAssets is an NFT standard for EOSIO blockchains that focuses heavily on RAM efficiency and usability. The created NFT can be backed by standard fungible tokens that will be freed once the asset is burned. This feature permits DApp to offer assets with intrinsic value. The standard's intriguing features are in the data structure and the data serialisation. The data serialisation can alleviate costs related to RAM usage and this happens within the contract to guarantee no corrupt data enter the blockchain. The structure has a top-down approach with the most general topic being at the top of the structure. Generally, the structure implements collections for DApps, schemas for the asset types, templates for the same kind of assets and assets for the actual asset.

dGoods: An open-source and free standard for handling the virtual representation of items, both digital and physical. Things like tickets, luxury goods, or even fractionalised ownership are well suited to this classification and therefore, a major focus of this standard.

SimpleAssets: A simple standard for digital assets on EOSIO blockchain: Non-Fungible Tokens (NFTs), Fungible Tokens (FTs), and Non-Transferable Tokens (NTTs).

Marble: Marble is a lightweight, highly customisable digital item standard.

Efinity Blockchain (Polkadot Parachain)

Enjin is working in collaboration with the web3 foundation and building Efinity on Polkadot. Efinity's purpose is to be an NFT highway, not a general computing blockchain. Token creation, transfers and purchases are the network's priority. Enjin is developing a token standard called Paratokens for Polkadot. The standard will be compatible with parachains, parathreads and smart contracts, so it's interoperable with the entire Polkadot and Kusama ecosystem. The ID of a token will contain info about where it's from and where it was minted, ushering in a super-efficient tokenisation system. Anyone will be able to tell exactly which blockchain network the tokens are coming from. Under the Paratoken Standard that introduces monetary policies, if you own a token you know exactly how that token will behave based on its policy. Another feature of Paratoken is known as extensions. This is a powerful way for anyone building on Polkadot to extend the functionality of tokens while building innovative practicality into them. One of these extensions, batch transfers, lets you send millions of tokens at once. There's also chunking, which basically allows you to send a range of them whether or not they fit into one block.

Cardano

CIP NFT Metadata Standard is the token contract relevant to NFTs on Cardano Blockchain. Tokens on Cardano are a part of the ledger. Unlike on Ethereum, where metadata can be attached to a token through a smart contract, this isn't possible on Cardano because tokens are native and Cardano uses a UTxO ledger, which makes it hard to directly attach metadata to a token. Cardano has the ability to send metadata in a transaction, that's how we can create a link between a token and the metadata.

NEAR Protocol

NEAR Protocol is featuring five token standards related to the NFT economy.

- Non-Fungible Token (NEP-171) is a standard interface for non-fungible tokens (NFTs). That is, tokens with a unique ID. NEP-171 builds on the experience of the ERC-721, and pushes the possibilities further by harnessing unique attributes of the NEAR blockchain. These include the following:
 - An asynchronous, sharded runtime, which means that two contracts can be executed at the same time in different shards.
 - A storage staking model that separates gas fees from the storage demands of the network, enabling greater on-chain storage (see Metadata extension) and ultra-low transaction fees.
- Non-Fungible Token Metadata (NEP-177) is an interface for a non-fungible token's metadata. The goal is to keep the metadata future-proof as well as lightweight. This will be important to dApps needing additional information about an NFT's properties, and broadly compatible with other token standards, An example is the NEAR Rainbow Bridge that can move tokens between chains.
- Non-Fungible Token Approval Management (NEP-178) is a system for allowing a set of users or contracts to transfer specific Non-Fungible Tokens on behalf of an owner. This is similar to approval management systems in standards like ERC-721. This standard provides a uniform interface allowing token owners to approve other NEAR accounts, whether individuals or contracts, to transfer specific tokens on the owner's behalf.
- Non-Fungible Token Enumeration (NEP-181) standard interfaces for counting and fetching tokens, for an entire NFT contract or for a given owner.

- Standard for a Multiple- Recipient-Payout mechanic on NFT Contracts (NEP-199) is an interface standard allowing non-fungible token contracts to request that financial contracts pay out multiple receivers, enabling flexible royalty implementations.

Algorand

This is the primary method a developer or Algorand user can use to build and deploy an NFT. It does so by using the ASA feature. This feature is a Layer 1 primitive that allows an NFT or FT to be created in seconds. These assets require no smart contract code. It only takes one transaction on the Algorand blockchain to create an NFT. This transaction describes the properties, both mutable and immutable, of the token.

Tezos

FA2 (TZIP-12) proposes a unified token contract interface, supporting a wide range of token types. The FA2 provides a standard API to transfer tokens, check token balances, manage operators (addresses that are permitted to transfer tokens on behalf of the token owner) and manage token metadata.

2.3 NFT Marketplaces

By comparing data provided by the data aggregator dappradar.com, we identify the following as the NFT marketplaces with the highest adoption as interpreted primarily by two metrics: number of wallets used the marketplace and total volume as captured in US dollars. For the scope of this research, we present the first five ranking marketplaces.

The most popular with a significant difference is **Open Sea** which is available both to Ethereum and Polygon Blockchain networks. OpenSea is the original peer-to-peer NFT marketplace. OpenSea saw USD 3.4 billion in trading volume across 2 million transactions in August. The marketplace is imposing a 2.5 % fee on sellers and accepting three currencies. It is supporting two types of sales: timed auctions and fixed price. The max file size is capped to 100 MB, while the most dominant categories within the marketplace are art, utility, collectables, trading cards, sports, metaverse and virtual worlds, as well as domain names. It has been established back in 2018 and enables royalties according to the artist's preference.

Rarible is the second most popular NFT marketplace. It imposes a fee on both ends of a transaction (seller and buyer) who are paying 2.5 % each. Rarible is community-owned by a Decentralised Autonomous Organisation. It supports slightly more currencies than OpenSea, while it has its own platform currency, the \$RARI; Rarible showcases two types of sales: auctions and fixed price. The maximum file size is capped to 30MB, while the dominant categories are supporting are art: gaming collectables, trading cards, sports, music, photography, metaverses, domains and memes. Rarible is active since 2020.

SuperRare is third in terms of ranking marketplace. In comparison to the previous two, it is curated more actively, while positioning mainly as a social platform to empower and promote crypto art. It is not acting only as a marketplace. Instead it works closely with artists, and has an approval system before a listing will be active. It imposes a 15 % fee on sellers, while accepting only \$ETH as a payment currency. It supports three types of listings: timed auctions, fixed price and open-ended offers. It is currently supporting limited file formats, with the maximum size to be capped to 50 MB. The main category supported is fine digital art. SuperRare has been operating since 2018.

Foundation is fourth in the ranking of NFT marketplaces. It has a 15 % transaction fee on sellers and accepts \$ETH as the main currency. It has its own sale model, which requires a reserve price to be met, which then enables a 24hr auction. The number of supported files is relatively limited and capped to 50MB. The marketplace mainly serves fine digital art listing, with specialisation in crypto art. The marketplace has been operating since 2020.

The fifth ranking NFT marketplace is the **hic et nunc** on Tezos blockchain. It has a 2.5 % fee imposed on sellers and accepting \$XTZ as the platform currency. It supports only fixed price sales and caps the maximum size of files sold to 40 MB. Key categories within the marketplace are fine digital art, collectibles, trading cards and photography. It was established in 2021. All sales are subject to a 10 % royalty fee on secondary sales.

Protocol fees for each marketplace are solely impacted by the market, and depending on numerous factors such as popularity of a marketplace, compliance expenditure, market positioning, size of the community, trading volume or even structure. Several of these NFT marketplaces are governed by their community through a Decentralised Autonomous Organisation, while others belong to corporate entities.

Chapter 3: Challenges, Future Prospects and Conclusions

3.1 Growing Volume of NFTs and considerations for Money Laundering

MONEY LAUNDERING NFT

The non-fungible token space has been very active over the past year, but there are concerns about the NFT involvement in money laundering and tax evasion.

In 2021, a digital artwork made history when it sold for EUR 61.6 million. The article by Beeple titled 'Everydays: The First 5000 Days' made headlines as one of the most significant signs of success and adoption that NFTs and digital art have ever seen. However, observers noted that when value is intrinsic the understanding of this value is made extremely difficult. And this can have substantial knock-on effects concerning taxation and movement of funds, or even be used as a new and more efficient form of money laundering.

Naturally, thanks to their digital nature NFTs do not need to be stored in a physical location. Moreover, most of the biggest NFT platforms operate with little or no KYC requirements. Bad actors may consider NFT marketplaces such as OpenSea, Rarible, and SuperRare as ideal venues for obfuscation of funds. These platforms function much like an auction house or an art dealer by connecting buyers and sellers who transact directly. The largest of these, OpenSea, identifies clients by an Ethereum wallet and requires no further information prior to allowing "private sales" of digital assets – NFTs in exchange for cryptocurrency.

NFTs can be rather complex. They are essentially a form of digital art that can be bought and sold while preserving the pseudo-anonymity provided by blockchain technology. Transactions are largely made in a trustless environment where counterparties cannot identify one another. There is also no verification of source of funds or even appraisal that a certain value for a digital artwork is legitimate or justifiable.

Money laundering is already a major issue in the art world, and speculation around such activity has quickly transferred to the world of NFTs. The popularity of the traditional art world has made it attractive for criminals who want to legalise illegal income. However, certain regulations surrounding appraisal and source of funds verification in this area is becoming stricter. This means criminals are looking for new tools to implement their schemes. The non-fungible token segment remains a grey area on the fringe of regulation, due to its complexity and pace of advancement the enforcement of anti-money-laundering remains a challenge.

It should be mentioned that the United Nations claimed the illicit art market was worth roughly USD 6 billion. And according to Jordan Arnold, chief innovation officer and global chair of private client services at risk and compliance firm K2 Integrity, the problem is likely to become worse as new art mediums such as NFTs emerge.

Money Laundering through NFTs

In theory, laundering money with NFT is very easy. Parties who want to launder money with the help of NFT follow a few simple and straightforward steps.

- Firstly, they create an artwork. These can be low-effort, even blank or generated algorithmically – in the past, such NFTs have sold for millions of dollars. Thanks to the availability of the metadata and code, fraudsters can create similar works by replicating the required algorithm.
- Secondly, they create the artists. Artist personas are often anonymous in the cryptocurrency world. Conversely to Beeple, likely the most widely known artist, Pak – a similarly prolific creator (or group) has never been identified. It remains unclear whether Pak is even an individual or a team. Behind this anonymous guise artists can mint an unlimited number of NFTs.

- Thirdly, they create a web presence, using servers in jurisdictions that do not cooperate with international policing efforts.
- Finally, they can trade their digital NFT using cryptocurrencies. Either inflating the price by buying many works from an artist at higher than market rates, or by acting as both the buyer and seller in a trade. This can be done by registering two separate accounts (one for selling and one for buying) and purchasing the NFT from themselves – a practice commonly known as “wash-trading”.

There are certain indicators that may signify suspicious activity, especially when the fiat value of trade is substantial. For example, a user buys NFT for EUR 1 million and two days later sells it for EUR 900 000 can indicate that the investor was either inexperienced or had planned the loss as a write-off. This may be an indication of money laundering.

NFT- KYC/AML GREY AREA

The NFT market currently is in a KYC/AML grey area, with no compliance regulations specifically required for the industry. Nonetheless, as with other sectors of the crypto economy, as adoption, usage, and volume increase, the regulators are likely to follow.

The fact that NFTs, like other digital assets, are issued on the blockchain means that the history of their transactions can be traced. The seller and the buyer of the token can be identified at the "bottleneck" of the proposed scheme during the conversion of cryptocurrency to fiat. This is the case since fiat to crypto conversion points (primarily exchanges) are increasingly transparent with regulators and law enforcement.

One particular area of concern comes with fractionalised NFTs. Because some NFTs are being sold for millions, the demand for fractionalised NFTs has surfaced – high-value artworks are being separated into tokens that represent ownership of a portion of the NFT as a whole. This enables participation of smaller net-worth stakeholders. It should be mentioned that the Commissioner of the Securities and Exchange Commission (SEC) in the United States, Hester Peirce, categorised fractionalised non-fungible tokens as unregistered securities. This means creators need to think about whether the NFT is being created to earn a return on investment. Also, investors should be careful with fractionalised NFTs.

Another feature is built in the royalty system which siphons off a percentage of every sale of an NFT at the time of trade and passes it to the creator. This creates a big AML issue for every creator whose work is sold on blockchain as they are no longer in control of to whom ownership passes.

FinCEN Informs Financial Institutions of Efforts Related to Trade in Antiquities and Art

In January 2021, the US Congress extended federal anti-money laundering (AML) requirements for the banking industry to antique dealers. The Ministry of Finance and other departments was also instructed to determine “which markets should be subject to regulation and to what extent such control should be focused on trade in expensive works of art”. This could soon expand to the purview of NFT platforms.

There is no definitive answer regarding what types of regulations apply to marketplaces, private sellers or auction houses. However, an implementation of any regulation of NFT platforms will entail the addition of basic KYC measures. This may in part address the problem of anonymity. Buyers and sellers will be identified by their real names and documents, and the source of their funds will be known before the transaction takes place. Marketplaces will also be able to track the sources of money coming in and the destinations of funds leaving their platforms. However, the issue is clear-cut since decentralisation, cross-border activities, and non-interaction with fiat all pose hurdles to such efforts.

Regulation on Markets in Crypto Assets (MiCA) & Money Laundering Considerations

The European Commission’s proposed Regulation on Markets in Crypto Assets (MiCA) is currently opting out the market of NFTs from the suggested regulation. MiCA excludes NFTs from its scope. According to Article

4 (2) of the suggested regulation “issuers of “crypto-assets that are unique and non-fungible” are not required to publish or register a whitepaper. Exemptions are applicable for identities given to NFT owners related to fractional ownership of third assets, or even particular rights linked to other financial assets such as distribution of profits, voting rights, or other entitlements. In such cases, regulators might assess those as security tokens.

An open question that merits further reflection is how NFTs might create the risk of facilitating the money laundering or terrorist finance crimes. Currently the great majority of NFT marketplaces are not imposing any KYC/ AML regulators.

European Union’s Fifth Anti-Money Laundering Directive (5AMLD), which went into effect in January 2020, has introduced regulation related to the art market as a target for money laundering. 5AMLD extends art dealers as stakeholders into the scope of anti-money laundering (AML) regulations in Europe. In AMLD5, artworks are now a category of ‘High Value Goods’ (HVGs) that carry a potential risk of money laundering. For art which exceeds 10,000 EUR, the legislation requires dealers to register with the government, officially verify client identities, and report any suspicious transactions. Such legislation is currently not extended to the NFT markets, which are subject to KYC free transactions through centralized and decentralized marketplaces.

Regulation on Markets in Crypto Assets (MiCA) & Money Laundering Considerations

Financial Action Task Force (FATF) is an independent inter-governmental body that develops and promotes policies to protect the global financial system against money laundering, terrorist financing and the financing of proliferation of weapons of mass destruction. The FATF Recommendations are recognised as the global anti-money laundering (AML) and counter-terrorist financing (CFT) standard. The Financial Action Task Force has released revised and finalized crypto guidance during October 2021, containing clarifications on who falls under its recommended requirements.

According to the updated guidance for a risk-based approach related to virtual assets and virtual assets service providers, Paragraph 53 which extends a reference related to NFTs, digital assets that are unique with usage as collectibles (rather payments or investment instruments depending on their characteristics, are generally not considered to be VAs under the FATF definition.

For the FATF, VAs are not merely the digital representation of value, they also have to have a tradable or exchangeable component. That value has to be able to be transferred rather than just a mode of record keeping.

The guidelines suggest that is critical to evaluate the underlying aspects and identities given to a particular NFT- and not limit the categorization based on the NFT tag which might be serving solely marketing purposes. Certain categories might be included under the FATF Standards, regardless of the terminology. Concrete references are given to NFTs used for payment or investment purposes in practice- which constitutes those NFTs as virtual assets.

Such assets are therefore excluded from the FATF definition of VA, but would be covered by the FATF Standards as that type of financial asset FATF definition. As suggested, countries should consider the application of the FATF Standards to NFTs on a case-by-case basis.

Under this recommendation non-fungible tokens (NFTs) don't appear to constitute VAs, but if they are used in such a way that falls under FATF standards, they should be regulated as such, even if their general use doesn't fit the VA definition. The FATF recommends a “functional approach” to regulating these new types of assets on a case-by-case basis.

“Some NFTs that on their face do not appear to constitute VAs may fall under the VA definition if they are to be used for payment or investment purposes in practice,” “Other NFTs are digital representations of other

financial assets already covered by the FATF Standards. Such assets are therefore excluded from the FATF definition of VA, but would be covered by the FATF Standards as that type of financial asset."

The NFT market has only started growing. It is important for participants to pay attention to the changing landscape and the platforms that address regulatory challenges.

3.2 Security threats, vulnerabilities, and challenges on the road to adoption

The year 2021 has seen a widespread interest in NFTs. However, this spotlight has not come without its share of controversies, criticisms and cybersecurity incidents. This section explores some of these issues and elaborates why they need to be addressed to ensure mass adoption of NFTs.

Cybersecurity incidents on NFT marketplaces

When the digital artist Beeple sold his artwork, *Everydays*, for a record sum of USD 69 million, it was a game changing moment for NFTs. The crypto community saw an influx of artists who wanted to explore NFTs for publishing their work. However, less than a week later, this landmark event was overshadowed [by a hack on the Nifty Gateway](#). The exchange issued a statement claiming that a small group of users who had not secured their accounts with 2FA (two-factor authentication) had seen their accounts taken over. Users had their NFTs stolen, or NFTs were bought on the marketplace with their credit card information and then stolen.

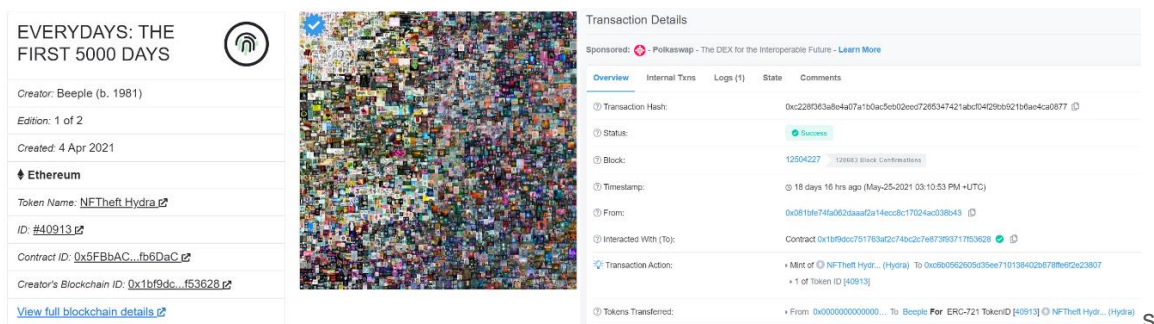


Figure 17: BEEPLE'S FAKE 'EVERYDAYS' SLEEP MINTED BY MONSIEUR PERSONNE

Less than a month later, news websites reported that an individual with the pseudonym Monsieur Personne (literally "Mr. Nobody") was running a project called "NFTheft" to expose vulnerabilities of the NFT ecosystem. As part of his project, he successfully minted a "duplicate" of the *Everydays* artwork under Beeple's name using a technique called "[sleepminting](#)". The artwork was also listed on OpenSea and Rarible for sale but was subsequently taken down, presumably once the marketplaces realised that it was a fake. This attack probably turned more heads because it managed to circumvent two of the biggest promises of blockchains – establishing provenance and ownership. Both these attacks call attention to the fact that NFTs, while promising, still need to address a number of security concerns before they can be adopted en masse. It is also worrying that platforms can delist an artwork, since they are prone to centralisation, with any impact this could have on the value proposition, regulation and economic model.

The hack on the Nifty Gateway highlights that NFT marketplaces need to move beyond depending on the tenets of blockchain when it comes to security. Conventional banking and fintech platforms follow established standards and protocols for securing customers private and financial information and for designing applications. These standards need to be applied to blockchain applications as well, especially to off-chain modules. Authentication mechanisms like 2FA need to be compulsory, similar to many banking and fintech applications. Additionally, it appears that the effects of the hack were subdued because customer private keys

were stored in a centralised location by the exchange. Hence, the exchange was able to revert the transactions. Experts believe that this raises more concerns since a crypto-experienced hacker could have dealt more damage. [They believe that](#) key ownership should be decentralised.

‘Sleepminting’ hints at a larger issue. [Several experts have tried to replicate the attack](#) to understand how it was carried out. They realised that an NFT contract creator can subtly change the ERC721 contract standard and mint an NFT to any Ethereum address and then transfer it back to an account under their control. This raises a security concern. Malicious individuals can falsely attribute that the NFT-digital art or collectible owned by them was created by a famous artist (such as Beeple) or was previously owned by a celebrity and thus charge a premium for it. This suggests that there needs to be a major design change in terms of how the NFT marketplace interfaces attribute the creator of an NFT. Other necessary measures, such as contract auditing before listing, and after-sale cooling period can be taken to ensure that malicious individuals cannot dupe customers, especially those not well versed with the ins and outs of the crypto world. Since the crypto ecosystem is unregulated in most geographies today, it is important that NFT marketplaces self-regulate for the safety of customers and their funds.

High Gas Fees

The dollar value of transactions on the Ethereum network in the first quarter of 2021 totalled 1.5 trillion, more than the previous seven quarters combined, and the number of transactions peaked at [1.7 million](#) in the second quarter of 2021.

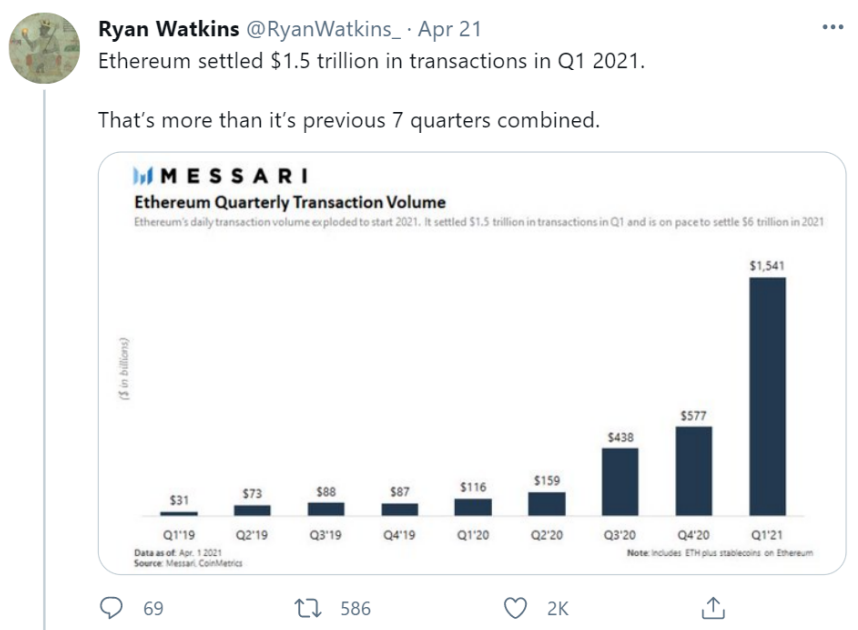


Figure 18: Ryan Watkins, Messari tweet on Ethereum dollar transaction volume

This spike in interest resulted in high network congestion on the Ethereum mainnet which in turn has drastically increased gas fees for transactions.

Since Ethereum is one of the most popular options for launching NFTs this poses a challenge for NFT creators and minters. Already ERC721 contracts require a higher amount of gas to be paid to the network. Couple this with rising gas prices and the price of ether, and creators often end up paying upwards of USD 300 for deploying their contract and minting tokens. Such high fees can be a barrier for new users.

Some innovative solutions have been proposed and implemented to reduce fees. OpenSea has introduced [the concept of 'lazyminting'](#). With lazyminting, tokens are minted on-chain only when the first sale happens. A token ID is allocated off-chain to the user when he 'creates' his/her NFT on the OpenSea platform. The total supply and user's address is encoded into the token ID which is referred when minting on-chain. A nominal gas fee still needs to be paid to register a proxy.

For long-term solutions, marketplaces are exploring scaling with Layer 2 solutions which have lower transaction fees. [OpenSea plans to integrate with Layer 2 protocol immutable X](#). Other marketplaces such as SuperRare are considering Polygon. Some are also considering integrating with Proof of Stake [blockchains such as Polkadot to reduce gas fees](#).

Energy consumption and environment concerns

The website, cryptoart.wtf (which is now closed), played a major role in raising awareness about the environmental impact of NFTs. It would allow users to calculate the carbon emissions [associated with commissioning an NFT](#). Since a large chunk of NFT tokens are deployed, minted and traded on the public Ethereum mainnet, they raise the same environmental concerns as other projects hosted on mainnet Ethereum.

Because of their environmental impact, the rise of NFTs has been met by major criticisms from all quarters, from leading tech mouthpieces to environmental agencies. Several artists who had initially embraced these NFTs for showcasing and selling their work have now decided to take a backseat. They have cancelled scheduled artworks or have decided to explore more sustainable options. Art Station, a digital marketplace for artists, cancelled its plans for an NFT marketplace after backlash from the community. French digital artist, Joanie Lemercier, cancelled the sale of six scheduled works after calculating the associated energy costs. She estimated, the sale would consume enough energy in 10 seconds to power his studio for the next two years.

Some supporters argue that the NFT creators are not responsible for the emissions. They believe the Ethereum juggernaut would chug on, with or without NFTs and miners would consume the same amount of energyⁱ. However, there are others that point out that multiple creators joining in on the NFT craze amounts to a large traffic on the network. [Miners end up investing in more sophisticated machines and consume more electricity to mine transactions](#).

Some marketplaces and artists have tried to explore 'greener' options. Artnome.com has announced a bounty programme for Green NFT initiatives. Others are buying carbon offsets before launching an NFT. Companies like Offsetra are selling these carbon credits. They also provide a carbon calculator to calculate emissions for any Ethereum addresses on the mainnet. Each carbon credit purchase is used to fund conservation work and is theoretically equivalent to one tonne of carbon saved.

Leading the trend, Nifty Gateway auctioned eight carbon net-negative NFTs ["inspired by Earth and the climate crisis"](#). The artworks were created by a set of digital artists including Beeple. They showcased a set of digital works on Blockchain that were specially formatted to be eco-friendly and have a smaller carbon footprint. Each artwork received a contribution of 60 carbon credits from RNDR network. The proceeds from the sale would go towards OpenEarth foundation, a project that uses technology to account for carbon in our environment.

From a technology point of view, NFT marketplaces are also exploring alternatives to Ethereum for minting and trading NFTs. Layer 2 chains such as Polygon (erstwhile Matic) and Immutable X are being looked at as potential sustainable solutions. As are blockchains like Polkadot and Flow, which focus on NFTs and use proof-of-stake for consensus. The arrival of Ethereum 2.0, which will rely on proof-of-stake, should also solve many of these problems and thus [marketplaces like SuperRare are donating to the project](#).

Establishing legal ownership of assets traded through NFTs

One of the major challenges that NFTs have to address is the challenge of ensuring that the underlying mechanism used for transferring and establishing ownership will stand in the court of law. Additionally, for the NFT ecosystem to be accepted by the masses, it is necessary to establish how NFTs will work with existing Intellectual Property rights in various geographies.

According to legal expert opinion, an NFT is like a property deed or an ownership title to a physical assetⁱⁱ. The deed or title is not the actual asset, but it entitles the person whose name is recorded to ownership of the asset. The only difference is that the deed is recorded on a shared blockchain ledger instead of a registrar or county clerk's office ledger. However, when you buy an NFT, what you get is ownership of the NFT itself. Anything further is decided by the terms of the NFT coded into the token smart contract.

Experts believe that, if an owner buys a digital art or collectible NFT, in most cases he/she is only purchasing the right to display a piece of digital art linked to the NFT. The copyright of the artwork remains with the artist, unless it is explicitly specified by including a transfer of copyright within the underlying asset represented by the NFT. This also means that Intellectual Property rights remain with the artist in most cases.

Even if the copyright is transferred, the author of the NFT remains the original creator(s). This distinction is important as it entitles creators to some important rights including the original ownership of their work. Several artists have seen unauthorised NFTs of their work pop up. This interpretation of copyright laws protects them.

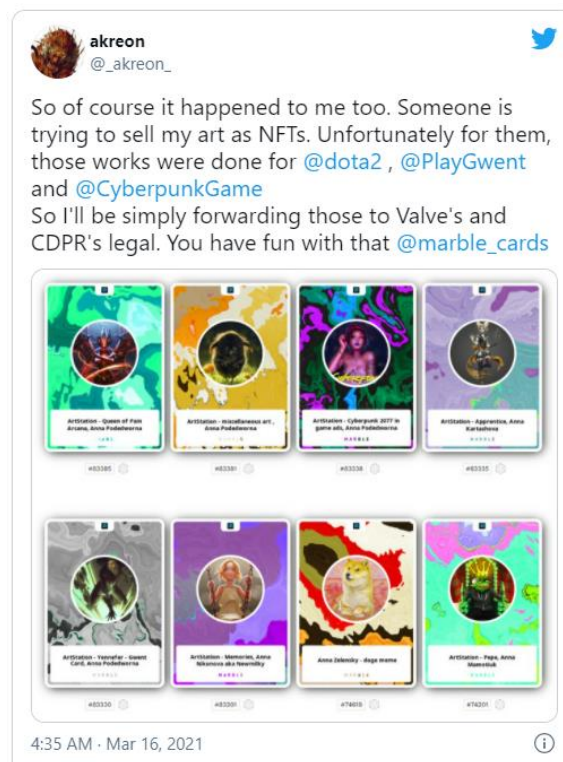


Figure 19: Marble cards, an NFT marketplace listed NFTs with URLs to the work of the digital artist Anna Podedworna without her permission.

It is worth noting that while NFT auction houses such as Duchampsⁱⁱⁱ (which sell NFTs for physical assets, such as limited Rolex watches) claim that the NFTs issued and sold by them are legally binding property titles, there is probably no legal provision that backs this up^{iv}. There is some debate regarding legally accepted frameworks for licensing, transferring copyright, reselling, protecting misuse and limiting the creator's liabilities

for NFTs. Minus any legalities, many of these tokens might amount to not much more than informal agreements between the buyers and sellers.

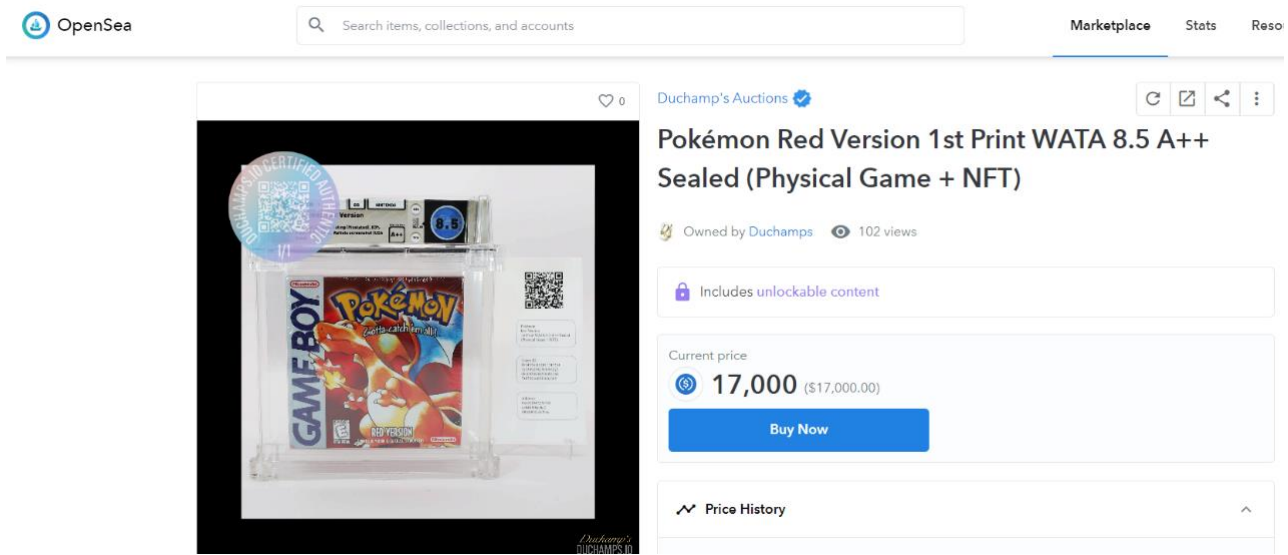


Figure 20: Pokémon Red cartridge listed as NFT for sale by Duchamps Auctions on OpenSea

This is especially troublesome in the case of NFTs representing off-chain assets. Many NFTs have been issued and sold representing physical assets such as antiques, collectibles, cards, etc. In these cases, the NFTs being sold are property titles for the physical assets and the seller promises to ship the physical asset to the buyer once the sale is complete on an NFT marketplace. The onus is on the buyer to ensure that he is trading with a trustworthy seller who will uphold their end of the bargain. Similarly, in the case of off-chain digital assets, if the token to asset mapping is not done correctly on chain^v, the buyer can be at the seller's mercy.

Dapper Labs, which built the Cryptokitties project, has tried to bring a legal structure to the process by introducing an open-source NFT license^{vi} which helps define the rights of owners, artists and creators of ERC-721 NFT tokens. Dapper Labs encourages other NFT projects to use the license as well and hopes that it will offer a middle ground between stringent copyright laws and artists completely open-sourcing their work.

Accessibility challenges for crypto-illiterate users

Popular NFT marketplaces such as OpenSea and Rarible require users to have access to a crypto wallet provider such as Metamask, Fortmatic or WalletConnect and have access to an Ethereum account to buy and sell NFTs. Similarly, minting new tokens through Cargo, Mintbase or Rarible requires artists and creators to have some basic understanding of blockchain or access to an expert. Creators need to make decisions such as which blockchain to choose, what token standard to pick, how to configure the contract and what currency to accept payment in and these are difficult decisions for someone new to the blockchain world.

This is a technology barrier for users unacquainted with crypto and trying to experiment with this technology. Most creators [have been relying on NFT marketplaces and artist communities for help](#). Artists such as Pinguino Kolb, who were early adopters, have been organising sessions to help colleagues and other enthusiasts. But marketplaces and minting platforms need to have more friendly UXs to further expand the community.

Nifty Gateway has managed to ease the process by allowing users to buy and transfer NFTs directly with only their credit cards. This makes it simpler as it eliminates the process of customers purchasing cryptocurrencies first to procure NFTs or to pay for transfer fees. However, selling NFTs on the Nifty Gateway still requires some understanding of the Metamask wallet and it could be unsafe for users to try the process without a prior

understanding of how it works and what they are clicking on. Similarly, OpenSea has introduced a collection manager that allows artists to easily create and deploy their NFTs on Ethereum. Due to lazy minting they are also able to allow artists to commission new NFT digital artwork for almost no upfront gas costs.

3.2 Industry Insights & Future Prospects

The benefits of non-fungible tokens can lead to the development and growth of an entirely new creator economy. The creator economy will focus on helping content creators avoid the need to transfer ownership of the platforms they use to publish their content.

As NFTs bring together content creators from all fields into one ecosystem, they can open up new opportunities for inclusive growth for all contributors. NFT creators benefit from efficient price discovery by a far more liquid and accessible art market – thus being able to value their creation and interact directly with their consumers.

Moreover, NFT creators are finding new ways to generate ongoing income – some platforms allow for a permanent royalty agreement to be embedded within the purchasing contract of an NFT, meaning that creators receive compensation with every sale. The original creator can receive royalties for each token resale as the NFT metadata includes the creator's address. Certain platforms such as Niftygateway and Superare have become popular amongst artists for this reason. As the technology and optionality improve artists increasingly turn to more efficient market structures to benefit from the changes.

Regardless of whether the recent hyper-growth of NFTs is sustainable in the short-term or not, legitimate use cases are starting to emerge. The future of NFTs will also rely on the imminent regulatory response and especially how the wider industry will accommodate for new regulations, especially those in the area of asset backed NFTs and proof of ownership and ID. Yet, artists, consumers, collectors, and investors are already benefiting from the new opportunities that NFTs enable in the areas of digital art, music, movies, collectibles, DeFi, and even real-world assets.

Walter Benjamin observed that much “futile thought” had been devoted to whether photography, and then film, were an art – and the important question had been missed. This is whether the very invention of photography and film had not transformed the very nature of art. Likewise, today, the question is not whether NFTs are a valid new form of art, but how will they transform the nature of art?

As NFTs can be applied to so many different types of digital assets, the question today is how will NFTs transform the nature of assets, and the nature of ownership and management of assets – not limited to digital assets but encompassing traditional physical assets and documents as well.

Current trade volumes are small in comparison to other crypto markets but they are growing at a brisk pace and have come a long way. In addition, Web3 wallets continue to develop, allowing interoperability and further facilitating interaction/integration with the technology.



The European Blockchain Observatory and Forum interviewed Dr Joshua Ellul to learn about the prospects of the NFT industry and to discuss the future prospects of the NFT market.

Dr Joshua Ellul is the director of the Centre for Distributed Ledger Technologies (DLT) at the University of Malta. The university runs a multidisciplinary Masters in Blockchain and DLT accepting students from different backgrounds including Computer Science, IT, Law, Business, Finance, Economics and Management. He was appointed Chairperson of the Malta Digital Innovation Authority, a world-first technology regulator that has put into place a technology assurance regulatory framework for Blockchain, DLT and Smart Contracts. Dr Ellul was recently appointed as an expert evaluator for the European Commission.

EU OBSERVATORY: Let's start with a question to set the stage for what we will be discussing. Because of the popularity of digital art, NFTs are mostly associated with just that, with art. However, we've seen many other use cases emerge and, in some regards, NFTs have picked up from where tokenisation left off, because it makes sense, our world is largely non-fungible. So, we've seen NFTs in real estate. We've seen digital-physical hybrids. I was wondering whether you could provide us with a definition and more importantly, a way of thinking about NFTs that encapsulates all the different variants.

JE: I would say NFT creates for us a verifiable proof of ownership, others call it a ledger. Call it whatever you want to call it, but there is this place where we can now check to see who actually owns an object, whether that's a digital asset or whether it's a real-world asset. So, my definition of NFT would really be providing a solution to prove ownership of an asset, whether digital or virtual. I think that's the best way to think about it. Now what that ownership actually means is a different story. And even if it's ownership, you could, I guess, consider that an NFT could be associated even with liability, perhaps, but I would say just clear ownership, - well, not clear ownership, but there is a digital record of ownership.

EU OBSERVATORY: We'll get to that. But how is this different from other ways we've explored in the past, in the decentralised space, that's just tokenisation using some standard that is not necessarily fungible.

JE: I would say really, and truly from a user perspective I do not see much difference from the unit or their point of view because he or she will have this digital asset or not really digital asset in their wallet, but their wallet is proof that they are an owner of this non-fungible token, which represents whatever asset in the real world now. Or if we had some other tokenisation mechanism, it was still proving ownership. So, without going into the details of the actual implementation and the interfaces and standards and interoperability, I would say that really, that is what it's about.

EU OBSERVATORY: So, we've established that we live in a non-fungible world, this is something that was discussed at length in our workshop. So, by proxy, everything can be represented as an NFT. What are the areas that you are looking into where NFTs can have the most impact and why?

JE: I think that's a very good point to mention that really anything can be represented as an NFT, even if we went to the extent that all notes or your own notes could be represented as an NFT, where each single note was an NFT. But does it really make sense to have each single note as an NFT? No, because typically the use case of euros or dollars or any other objects like this, where one equals the other and they're interchangeable and there's no unique value associated with that object or whatever it may

represent. I think definitely don't use NFT for that. But when it comes to the real world and we're talking about my specific Lamborghini, and I wish that were true, or a Mona Lisa, that is where an NFT provides particular ownership capabilities that we didn't really have a mechanism for before. Because before we would ask to trust like our land registry to prove that we are the owner of our house, or you would have to physically own an object to be the owner of that.

Or you would have to register your car with the transport authority. And this isn't really resolving those issues that have to do with NFTs. What NFT is providing is so far a digital way to represent this ownership. So far, if everyone in the world worked to honour this digital ownership that the blockchain says it, therefore it must be yours, it's a great solution. And building on that solution, I think we can come up with some really interesting use cases. So where are we using NFTs now? We are seeing use cases of NFTs in land registry, art ownership, very expensive object ownership. Some people might ask why you don't use it for inexpensive objects, there might be something sentimental in me. Depends on the platform but given that there are costs associated with transferring the token, let's say in Ethereum, you'll need to make sure that that cost is actually worth it. And there are different platforms out there, I believe that in time we will be able to see cheaper objects, whether digital or virtual also be trackable using NFTs as well. And we can start to think about this world that I am not sure whether it's a rule that will ever come, but sort of this world of a tokenisation of everything, where everything is tokenised and perhaps linked to a lot of people, we are now talking about a metaverse where there is this digital world out there connecting to our real world. We can get there.

EU OBSERVATORY: I want to try and better understand the unique value that NFTs bring to the table. So, what you discussed now, is that we can sort of apply NFTs to some areas where they are traditionally very inefficient and expensive, whether that is for registering, ownership, for transferring, for trading. And this is intuitive. My question is that we know that NFTs come with the usual benefits of blockchain backed applications. Those are also found encrypted, cryptocurrencies and tokens, this immutable vessel, they're transparent, not centrally controlled. Are there any other unique aspects that NFTs bring to the table that don't necessarily rely on the blockchain and are not necessarily served by cryptocurrencies?

JE: That's quite a tough question. And if I were to go to the discussion of decentralised system tracking, I can go to ownership or tokens in a decentralised system versus the centralised system. I would say that what the NFT brings is equal across both almost, except for obviously the decentralised that now you're trusting us centralised maintainer. But also, in a decentralised world where we have NFTs, we can now start to build open standards and open applications where we can build modular use cases for NFTs, because it is open, because there is no one that you need to convince to allow for your application to run. So, I think by having a decentralised register of NFTs, rather than a centralised one, we will be able to build on this NFT world application more quickly. I think that is one benefit that NFT in the decentralised world brings.

Whereas in centralised world, there'll be too many bureaucratic problems to go through and even adopting by whatever the centralised party wants you to adopt. And I'm quite sure we're going to see different standards, all types of different applications, sharing of token between applications that might be proprietary in that sort of bubble or different bubbles. But that's the beauty of this open community that over time, the best but the ad hoc standard will win and we all start to adopt. And I think that this is the beauty that a decentralised world is bringing. Everyone out there is putting their brainpower to see how to build these solutions. For me, that's the defining difference.

EU OBSERVATORY: There are certainly building blocks for other applications, right? So, we're not talking about digital-only versus NFTs with physical counterparts, which over the two, and we spoke about the metaverse and if these are presenting traditional assets, but which of those two categories of the NFTs physical counterparts or digital-only NFTs is most interesting to you and why, and which one do you think will have the most potential in the future?

JE: So, I would say one with the most potential in the short-term, is using NFTs for real-world assets. However, the caveat is that we'd manage to build the other infrastructure outside of the digital world to honour that ownership, but that's a very easy link to build. And I think this is going to be a short step towards a low-hanging fruit. As for NFT for the digital world, I must say at the same time thinking about it now, could just as easily be implemented by our gaming companies which allow for me or you to have a particular sword that is transferable into another universe. So, I think technology-wise, they are both quite low-hanging fruits. Now, if I were to voice that further and not think about technology, so we can achieve this, knowing how people work, how institutions work, I now start to believe that getting digital NFT tokens, representing some digital artifacts, can gain whatever it may probably is, what we're going to see much sooner, because it is the tech industry that's going to be pushing this and the games industry and our bureaucratic systems are too slow. So, I'm starting to see that now one could be in the digital world. The use cases are there for both. But I think in the gaming sector, we will see a heavy reliance on NFTs perhaps also in the gambling sectors as well, and maybe even in some sort of software particular types of systems. I believe that's going to be the short-term, but then obviously there will also be the digital ownership of digital assets which we're already starting to see pick up. The big question there though is "who defines ownership". And I'm not sure if we're going to talk about this later, but there's the issue of IP. Like, can I just wait on an art piece that everyone has access to hatch it and data it, I own it?

EU OBSERVATORY: This is exactly what I wanted to ask. Can you give us an overview of the complexity that goes into defining the ownership of an NFT?

JE: I would say if we start by looking at ownership in the real world, without going into legal terms of how exactly ownership is defined and how it's defined in the law, but we all understand that ownership is: if I have an object in my house and no one can contend to that object, then I'm the owner. I'm the rightful individual to whom that object belongs to. And I'm sort of defining ownership by owning, but we know what the term means. It's mine! Now, when we come to having a more formally accepted solution by society, not just the fact that my neighbourhood, my community, people who know me, know that I own that object, the legal system will also honour the fact that I am the owner of that object. Besides providing some proof, some receipt of purchase, we also have different types of registries that we use in the world.

So, we have a registry, I am the owner of a particular car. We have a hundred trees or four homes. And we may even have registered that certain manufacturers, perhaps diamond manufacturers keep track of certain cost diamonds or high, very expensive cards, keep track of the owners of those particular diamonds or cards. That's great because we have a centralised registry of ownership where we trust as individuals and whom we trust in society, or at least we're supposed to, because those are the structures that have been put in place legally. And if someone steals that object away from me, I can take them to court. I can get legal recourse and get that object back. Now, when it comes to digital ownership, when it comes to NFT ownership, the first part is the fact that I've come through that in my wallet or associated with my wallet. There is a particular object associated with it. I think it's very important to the client that the hope in itself is not actually in the wallet from a software perspective.

What's really happening is you have essentially the equivalent of a username and password and is your public key and private key. And there is a record on a blockchain proving that your account is connected to that, which we could say is the owner of that NFT. So that's step one. I can now prove using a blockchain that it's connected to my world, which we will for now assume that means "I own it", but do I really own it? Let's say it is a sword in a game. I'm the owner of that sword. I can use that sword in the game. No one can take it away from me. But there are two problems. Now I want to get into one is the fact that in this type of ownership of a sword that only I own, I could with relative ease prove, that I am the ownership by showing them the sword using it in a game. Versus when we're talking about digital arts and you are the owner, because again, there is a record in the blockchain tying your accounts to that digital arts piece not directly, but indirectly, and you might think that you're the owner. And the way that this works is because the digital art piece isn't actually stored on the

blockchain, what happens is you act that information, digital art, and you end up getting this unique identifier, associated with the IP. So, with this unique ID, I can always prove that that unique ID belongs to the art piece, no matter what, we can all check this around the world. And in the blockchain, I have a link to that unique IP. Now, the problem is that anyone else in the world can also create the new records, proving that out is the same unique ID, the same unique identifier associated with that digital art piece. So, I think that's where ownership gets much more complicated because who is the owner of this digital piece? Now that there's two: A person might say, it's the first person to upload it to a blocking, even though I don't think that's the right way of going about it, let's assume that two people uploaded at the very same time if that's what we believe, you still have the same problem.

So, I think from a game's perspective of ownership there are lesser problems that will need to be tackled immediately because if you have that sword, no one can take it away from you unless they steal it from your wallet. Now, if that's the case, perhaps you can prove that it was stolen from your public-private key and perhaps the law courts or the game provider might manage to get you your swords back or create a new sword. When it comes to digital art ownership though, I do not see a solution that's proving that ownership. So, if you need to prove that ownership in a court of law, for some reason or other, I do not see a way of doing that yet, because we need centralised points to tell us who is the owner of that piece.

It gets quite complicated once we move into the digital sphere. And even when it comes to this sword token, the issue is that we can give you this sword in the game, it's actually a token where when you log into the game and the game provider sees that you own the sword and he gives you that special sword. Now someone else could log in to the game and you could also be given the same sword because it's governed by a central game provider. Indeed, they're looking at the blockchain, but at the end of the day, the game providers providing that solution. So, there's a lot of caveats and opening up more questions rather than solutions at this place.

EU OBSERVATORY: I was also wondering if there's a way to mitigate those problems that you're describing. My first question would be, do you believe that some form of decentralisation is easily wired in order to resolve those issues? What would be that form of intervention?

JE: I think there needs to be some form of centralisation around this problem. Now that centralisation isn't necessarily a centralised authority, what I'm saying is that centralisation needs to be at a single point of reference. And that single point of reference could be a de-centralised network. It could be a blockchain, but we need that single point to refer to. We can't have the possibility of owning the same sword in two different blockchains or two different smart contracts. We need a single point of reference. Now, whether it's a centralised governing it, or whether it's a decentralised ecosystem, doesn't matter, but we need that single point of reference. And even if we have that, it still creates problems. It could work talking about a digital world where people from around the world without boundaries can join in, but in the real world, we live in different jurisdictions with different laws, governing ownership.

And is that going to impact my rights, if in the digital world the fact that I am the owner of a particular piece, but in my land of jurisdiction, it's claimed otherwise, do I lose those rights? And is it going to be given to someone else? Unfortunately, we live in a world governed by different laws. So definitely when it comes to, let's say games and there is transfer of tokens associated with your tokens, whether it's a sword or whatever, the game operators could come together to build a trusted, unique reference. And I think that would be a great step forward. And it doesn't necessarily just need to be the gate providers. It could be the development of decentralised developers around the world with the game developers and companies who come up with this ad hoc standard. And I hope that's the direction that it takes.

EU OBSERVATORY: In any case, it would require some form of coordinating the response from a large set of people, ideally. Whether that's regulators, whether that is a community. We will touch upon some of those issues in our next question, which pertains to NFTs with physical counterparts. So intuitively we

understand that those will require a physical to digital bridge, again, in the form of some central coordination. So, I was wondering whether there are any additional challenges with regulating. You just told us why regulating digital NFTs is very hard, but are there any additional challenges with regulating NFTs with real world counterparts and even if it's harder to do than digital only NFTs?

JE: So, let's first talk about ownership of an object and the complexities. To prove the fact that I am an owner of an object, if I need to in a court of law, and we may have a difference of opinion of who is an owner because of initially shared ownership that became sole ownership, we also may have objects that have transferred between different jurisdictions, where the legality of ownership might differ. And so, in one country, you may be able to own a particular product, but in another country, it may be illegal to even own that product. Now, this becomes much easier in the digital world and the digital world we don't need to physically transport, they can instantaneously transport and access that digital asset. And if we have the same problems that it might be illegal for me in one country to own a digital asset that is allowing for me to gain shares on my investment, whereas in another country might be perfectly fine.

And so, we have the problem of different jurisdictions. Now, besides that when it comes to digital ownership of a digital object, let's say of that sword, if we have this consolidated single approach, or at least some, I will take acceptable belief within the wider community of what this represents. I think the ownership might be easier to prove in a court of law. Yet there are still some problems, but it's easier to prove, but if we do not have that coordinated approach to the guy who is the owner of something, then it becomes difficult. So, the more decentralised we go in terms of having a decentralised ledger, where there's no single coordinator to agree upon a point of reference, then it becomes hard to identify who is the owner in the real world of that digital object. That's when the token itself is the object. Then it gets more complicated when the token represents a digital object. Just like we said before I can have a token saying that I am the owner of this popular meme video or something. But how did I become the owner? It's somebody who has uploaded. Are we allowed to do this? If at the end of the day, it depends on the law, and it depends on the law if you need to challenge it? But I think we're also moving into a space where we're living in a world where certain claims, perhaps aren't being challenged, where just because I did buy that single pixel with that hash, people are honouring the fact that I am the digital owner of that, and they're intertwined in this niche community. So, are we even challenging what ownership means? And if that gets approved, we have a link from one digital token to other digital objects.

We really know if you are the owner of it, we may honour it, but the legal system might not. Then it gets even more complicated when we're going from a digital token or a real-world object, where you might have the object in your house, but I say, you know, I'm the owner. It depends, or could we come up with new terminology, define middle ownership that has lesser rights than physical ownership? And so, I think this is quite complex and it does make me wonder why we would pay so much for digital ownership of something that I cannot necessarily prove in the real world that I am the owner. I think we need some clarity in that space. Because I think a lot of people could end up getting burned by thinking they're actually buying something and not understanding what exactly they're buying.

EU OBSERVATORY: I do see where you're coming from and I will shuffle some of the questions. I understand that this is complex. So, I will change my follow-up question on how regulators can even start thinking about regulating this area. You mentioned in the workshop, there are some areas that we should avoid, like regulating the technology as a whole. But I was wondering whether you could speak to how regulators should best approach it.

JE: So, I would say one aspect, and this is an aspect I keep pushing on, all regulation of blockchain-based systems, is we need to make sure our current code is working correctly. And we need to make sure that the token implementation will actually allow for you to keep me as the owner and not suddenly disappear or really get locked away. So, we need to make sure that the code cannot be taken away. The token cannot be taken away or locked away. So, assurances are very important yet at the same time, even though I am the

chair of a regulator that does this work, we cannot impose this requirement on technology. We cannot stifle technology. So, we need to be identifying which sectors, which uses of technology require such assurances. For example, when we're talking about financial ownership of objects, of expensive objects within the financial community, definitely there should be laws in the financial regulation defining that code must be fit for purpose. That's one aspect. Then the second aspect is how do we actually handle the sector ownership? And I think rather than focusing on saying we're regulating NFTs, we're not really regulating NFTs because we're calling the NFTs today which have a particular instantiation, but there could be some different form of keeping track of ownership tomorrow.

Perhaps I think what we should really be focusing on is regulating ownership. And now keeping in mind that there is this new technology that we need to factor in within this ownership field of regulation. And that definitely requires – I'm not saying we need to be as technology-agnostic as possible – insight as regards to what challenges these technologies bring. So, we need to install principles, if someone is rightfully the owner based on what we would expect to be right for, that individual should never lose that token. We should have regulations in place to support this. Moving away from this discussion because I think that's the limit to what they can bring to the table on that part, I think as regulators, we could provide solutions. We could provide a centralised point of reference to this problem. Why could we not around the world, come up with, and I don't know who the right regulator would be for this, it could be a financial regulator, it could be a new regulator, it could be some sort of new ownership regulator, but why can't we around the world come together and say, there's this technology now that allows for us to keep track of digital ownership, why not create a point of reference to make it easier for people to understand if they are the owner or not. And I think that would be an excellent way forward. That's the low-hanging fruit. It provides legal certainty now and it can also encourage businesses in that space. The problem is coming up with a global approach. It's going to take a long time. We see different countries, take this approach or jurisdictions. Perhaps Europe can take this approach, create an ecosystem, digital world and create harmonisation. I think that would be a good path to start investigating. Then there are still problems with it and we need to think about these problems. When I am the owner of a particular token, I might have the public key and the private key and what if it's stolen from me unrightfully? How do we get that back? Should we have some mechanism where this coordinate ledger, could there be some powers that can take that back away from you, that goes heavily against decentralisation. Do we really want that? Then what about on the other flip side, what about when I pass away and all my NFTs are locked in my wallet? How do I pass those on? Sure, there are solutions for custodianship but what happens if I didn't set them up though? So, these are the problems. I think that unfortunately we don't have the solution and it's not because we can't create a solution, it's because we actually do not know what that solution should be. We're talking about creating decentralisation versus having a way to intervene when it's required to intervene. But then we need to take away that decentralisation.

EU OBSERVATORY: Does the solution defeat the purpose of the system?

JE: Exactly maybe what we should do is try to support the spectrum. Say you are here owning that completely decentralised token. If you lose it or it's stolen, there's nothing we can do about it. Why don't you might have a separate version saying, there's a consortium of elite or the people who believe they can judge ownership and they can intervene if required. I think that could be a potential solution. However, there are problems with that. I'm assuming an educated individual in this space, someone who can make this decision and take this risk for himself. And it's not the case that everyone has this level of education. So, this is where I kind of understand when centralised laws are right to impose, because they know that society themselves do not have the knowledge to make these choices. So, I don't know if I could make a choice. I think I would be able to continue. We're creating these systems before you sign up, you must have very clear conditions. Do you accept, yes or no? But I'm a bit progressive in that aspect.

EU OBSERVATORY: You spoke about the importance of making sure that the technology does what it is supposed to do, because without that you have a fragile basis upon which there is no point in building anything

else. Since 2018 Malta has introduced a regulatory sandbox in part for addressing what you just mentioned. How does this regulatory sandbox help NFTs in particular?

JE: The sandbox was introduced in 2018, the financial regulator put into place crypto regulation, which is called MFSA, but you know the whole crypto regulation regime and the crypto regulation regime in Malta requires one to take a system audit. So, you need to make sure that your technology is fit for its purpose. But knowing that we're starting, we want to support the startups, the industry, the people who are actively taking this forward and they can support these fully-fledged system audits. And so, we thought, how can we fit this into a regulatory regime where we're providing some assurance to the end-users. So, we thought about scaling down costs whilst the only way you can scale down costs is, you're all sort of scaled-down risks, unless you're willing to increase high risks without having enough quality, but that's not acceptable. I think if we're having a stamp, seeing that something is fit for purpose, so let's limit the risks. So, we came up with the idea of a technology assurance sandbox at the MFSA and this was launched 2 months ago or so. And the idea is that you're not in a position as an operator yet to undergo a full-fledged audit, you haven't really started up and you're not dealing with millions of flights and handling all sorts of high amounts of Euro financial assets.

You're in a position where you want to start testing out the field. So, let's limit the risks. Let's say in the beginning, you're only going to take on a thousand clients in the first three months, let's limit the number of transactions that you can pack the regulator with. You'll come up with this plan. And as you start to meet the milestones, the risks and the size of regulation that we're putting in will all scale up. And the intention is to get to the point where you reach the end of the sandbox, where you're no longer going to be a sandbox resident, and you're going to leave the sandbox into the real world. And at that point, we hope that you could undergo a fully-fledged system audit. However, getting to this process and getting there, you'll be having the fork to give you the stamp of approval.

You know, we've looked at these particular processes or these control objectives, they're fit for purpose. This allows for you to go out to your users and say, guys, this whole space that we're talking about at the end of the day, NFTs, DeFi is heavily experimental. Now, imagine you go up to a few thousand, Hey guys, we're testing this out for now, are you willing to take part? I think a lot of users, knowing that there's less likelihood that there could be problems with the solution would be more money. Number one, number two, if you want to not only convince the users, if you want to come from investors, they're the stamp of approval from an actual authority. So, this could help to scale up an operation. And so, where do NFTs fit within this? I think someone developing an NFT solution, whether it's a custodianship, whether it's a market, whatever it is, they could use a technology sandbox-like platform to build these assurances, because we've all seen where something goes wrong. Let's give some peace of mind to our end users. So, I think that there's definitely a win-win situation for NFTs in this type of sandbox.

EU OBSERVATORY: If sandboxes are a choice that works, why haven't more countries or even the EU as a whole developed the same similar initiatives?

JE: I think one issue is that a lot of what is happening regarding regulation into the blockchain space, is not regulated in the blockchain space, but it's regulation in the crypto space and the financial world. I think we need to start having more individuals, more technocrats focused on understanding the challenges in the technology, not the challenges in financial regulation. And I'm not saying we should then regulate the technology. I think we should just understand the challenges and then see how those challenges fit into sectors or activities. I mean, even if we talk about running a marketplace, if I tell you what your marketplace can and cannot do, I'm not regulating the technology. I'm telling you what the marketplace can do. So, it's not easy to do either. I mean, I must admit because when it comes to different authorities, different regulators who all have their vision, it's very hard for them to go outside of their comfort zone. And it's very hard to set up new bodies as well. So, I think education is important for policymakers. That being said, I'm under the impression that the EU is pushing the sandbox, not for this, but there are mentions of sandbox-like structures for the AI act, the AI regulations, so that's positive. And it's even great to see that the US is proposing a technology-

focused regime, even though I still think that the mandatory regulation should come from an activity or a sector point of view, not because they're using a particular technology, but I think it is a step in the right direction. Now another reason why I think we haven't seen sandboxes because really, and truly the world is still catching up with crypto. The regulators' governance structures are still catching up with what crypto is and what to do about crypto and security, tokens and DeFi. And now, honestly, I think they're like NFTs as well. Can we say it's not financial, it's someone else who handles that? I think there's a bit of that going on because there's so much work to do.

EU OBSERVATORY: I have one last question that has to do with the future of the industry. If the NFT vision is to be realised, as we discussed before we mentioned the metaverse and other applications, what kind of applications would you expect to see in the short term, within the next two years, and in the long-term, within the next decade or so?

JE: So in the short term, I would expect to see a lot of exploratory uses of NFTs and many isolated systems. And I'll come up and give myself some time to even think about those systems. But the reason why I'm saying this is because it is going to take time for a company to come on board. And I think the long-term, the 10-year vision is to have companies using an NFTs structure, that is interoperable, where your tokens are no longer locked into a platform, whatever that platform is. You actually have ownership of that token to pay it literally anywhere you want. And to get there, we need companies, we need blockchain infrastructure platforms, all the different entities, governments to really be open to this potential ad hoc standard that emerged.

So, I think in the next two years, we'll see a lot of applications for physical object ownership. I think cars, land registry, government, we'll look into it, but that's a very slow transition because I imagine what would happen is, the land would be transferred from the old system to the new system. So that takes a very long time, but keeping track of very expensive objects, I think that is something we will see within the next two years. Most likely find quite proprietary isolated systems. So, I'm guessing we'll have a few different apps, look at the ownership of our different objects and you can transfer the object now by selling it online, not even meet the person, and we might be able to sell them this physical object.

Now, one of my questions is "But we can already really do this in real life?" Right. Just put it on a marketplace and sell it. Definitely. So how does this differ? This differs in the fact that you can sell an object without even having it in your house, you can keep it, let's say at someone's place, and yet you are the owner and you're earning money on it. You might be able to lend out objects that have never even landed in your house. So, I think there's a term for that, but I forgot what it's called where you're making money on objects that you have never even touched. So, I think ownership, registries, proprietary ownership registries will be played popular in the next two years. I would say game digital, game ownership of tokens and tokens of objects of utility in games and anything where we can associate digital ownership with some feature in the software, some feature in this metaverse, I think that would become popular even for software rights usage in the past, there is a point where a lot of people were using USBs and all sorts of devices to give you opposites software. I think this will change over to poking ownership and you might have a hardware ledger or it might be in your wallet.

The whole digital ownership space, I'm honestly not sure what's going to happen there, whether it will continue or whether people will start to raise the concern surrounding whether they are the owner of a piece that everyone can copy. I would hope to see, and this is possible in the next two years as well, some manipulation of the real world. So, a physical object might be an advert display, whereas if I hold the current token, I can put my advert on this physical display. This is connecting the decentralised ownership world to the centralised world because that billboard out there, someone must own it. We still don't have structures in the world to allow for decentralised ownership of physical objects. So that's where I see it within the next two years. I would say within the next 10 years, then it's more about interoperability and owning those tokens outside of proprietary platforms. So, what actual use cases would there be for that? Whatever tokens we can envisage now, it gives them more power to bring those tokens anywhere with you. Obviously, if we're talking about a piece of land in

the land registry, it doesn't need that feature of interoperability because if you're governed by the laws of land, you don't need to operate with other laws. But if we're talking about game token ownership, I would say in the direction of digital ownership, that would be the pillar direction and be quite honest, I hope, what I'm currently envisaging for the usage of an NFT, I think it's very limited based upon the period of exposure I've had to the world that I know, that has always been about real-world physical ownership. And I hope that in 10 years there will be all sorts of uses of tokens. I can't even envisage because I don't understand what this will mean, to own digital objects. So, I think that there's going to be a lot of surprises.

3.3 Policy Recommendations

This section proposes a set of policy recommendations based on the topics addressed in this thematic report.

The interest in Non-Fungible tokens has exploded within the last year – increasing dramatically the number of users, investors, marketplaces, NFTs, and resources allocated in this fast-growing market. Despite the growth of the NFT markets, we are still very early in the development and real adoption of NFTs. As a result of the early market development, we might not be able to separate the short-term growth hype from a sustainable and mature market.

Regulation on Markets in Crypto Assets (MiCA) & Money Laundering Considerations

[1] The European Commission's proposed Regulation on Markets in Crypto Assets (MiCA) is currently opting out the market of NFTs from the suggested regulation. MiCA excludes NFTs from its scope. According to Article 4 (2) of the suggested regulation issuers of "crypto-assets that are unique and non-fungible" are not required to publish or register a whitepaper. Exemptions are applicable for identities given to NFT owners related to fractional ownership of third assets, or even particular rights linked to other financial assets such as distribution of profits, voting rights, or other entitlements. In such cases, regulators might assess these as security tokens. This approach to NFT's may change, however, if Parliament or Council request amendments to the Commission's draft.

[2] An open question that merits further reflection is how NFTs might create the risk of facilitating the money laundering or terrorist finance crimes. Currently the great majority of NFT marketplaces are not imposing any KYC/ AML processes, which may change in the future. The European Union's Fifth Anti-Money Laundering Directive (5AMLD), which went into effect in January 2020, has introduced regulation related to the art market as a target for money laundering. 5AMLD extends art dealers as stakeholders into the scope of anti-money laundering (AML) regulations in Europe. In AMLD5, artworks are now a category of 'High Value Goods' (HVGs) that carry a potential risk of money laundering. For art exceeding 10,000€ in value, the legislation requires dealers to register with the government, officially verify client identities, and report any suspicious transactions. It is unclear whether such legislation also covers NFT marketplaces.

[3] Financial Action Task Force (FATF) is an independent inter-governmental body that develops and promotes policies to protect the global financial system against money laundering, terrorist financing and the financing of proliferation of weapons of mass destruction. The FATF Recommendations are recognised as the global anti-money laundering (AML) and counter-terrorist financing (CFT) standard. The updated guidance (2021) for a risk-based approach related to virtual assets and virtual assets service providers includes Paragraph 53, which contends that NFTs, digital assets that are unique with usage as collectibles (rather than payments or investment instruments depending on their characteristics) are generally not considered to be VAs under the FATF definition. The guidelines suggest that is critical to evaluate the underlying aspects and identities given to a particular NFT – and not limit the categorization based on the NFT tag, which might be serving solely marketing purposes. Certain categories might be included under the FATF Standards, regardless of the terminology. Concrete references are given to NFTs used for payment or investment purposes in practice –

which renders such NFTs as virtual assets. As suggested, countries should consider the application of the FATF Standards to NFTs on a case-by-case basis.

Copyright

[4] Among the most important aspects related to NFT regulation, is the respect of ownership rights. There are instances of the distribution of artwork without the copyright owner's permission, and similar copyright violations. It might be beneficial for the creative economy to adopt and monitor the enforcement of copyright legislation to clarify in which cases an NFT entitles the owner to the ownership of the item associated with an NFT.

Distribution of Royalties

[5] Different token standards enable the collection and distribution of royalties, which are delivered to the issuer of the NFT for every resale of the NFT on secondary markets or as specified in the self-executing programmable identities of the NFTs. Programmable distribution of royalties for the reselling activity of NFTs might be beneficial to be harmonized with the applicable legislation. NFTs allow a paradigm change in how we manage copyright, namely that the creative artist gets remunerated during the first sale but also receives royalties if/when their artwork accrues value due to exposure, recognition of the artist, or other factors.

Supporting the EU economy

[6] Artists have been among the most affected professions due to the pandemic, hence NFTs might act as a boost to support the creator economy. NFTs are highly innovative technologies, with a clear market value proposition, which might nurture a new techno-cultural movement. It is recommended that the EU supports NFTs through European projects aimed to promote culture, arts, and youth creativity.

[7] Generally, a clear European policy regarding NFTs will support entrepreneurs to choose EU member states as their base, while supporting the creation of new jobs in the EU.

i <https://medium.com/superrare/no-cryptoartists-arent-harming-the-planet-43182f72fc61>

ii <https://www.lexology.com/library/detail.aspx?q=d96ed012-8789-4e87-bc1d-70ba76569c0f>

iii <https://duchamps.io/info/how-it-works>

iv <https://www.legalcheek.com/lc-journal-posts/what-the-non-fungible-token-craze-means-for-ip-law/>

v <https://medium.com/coinmonks/ethereum-nft-token-to-asset-mappings-are-off-chain-and-nobody-cares-4aff301382b0>

vi <https://www.nftlicense.org/>