

# Analysis of potential NFT applications

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**Abstract**— The Non-Fungible Token (NFT) market has seen a huge leap in popularity in previous year (2021). Sales of nonfungible tokens have increased from \$82 million in 2020 to \$17.6 billion in 2021 reflecting a huge spike of interest in the new technology. Over 2.4 million new crypto wallets started trading NFTs in 2021, as compared to only 89,000 in 2020. This sudden increase in popularity has attracted huge attention from industrial and scientific communities. It was widely debated whether NFT ecosystems are the next step in the internet evolution, or they will never find their place in the real world. The non-fungible token technology is in its early stage, and currently it is mostly used in collectibles, arts, and gaming industry. In this paper, we will explore other possible applications of NFT technology in the future.

**Keywords** - NFT, Ethereum, Blockchain, Smart Contracts, dApps

## I. INTRODUCTION

Non-Fungible Token (NFT) is a type of unique and indivisible blockchain-based crypto token, introduced with EIP-721 (Ethereum Improvement Proposals) [1]. As opposed to other, classical cryptocurrencies which are defined by value, NFT's cannot be interchangeable for other tokens as they are defined by their own unique properties [2]. They give us the ability to assign or identify ownership of any unique piece of digital data, trackable by using Ethereum's blockchain as public ledger. Historically, NFTs were mostly used to represent ownership of digital art and collectibles, but they can also be used to represent physical and real-world items such as deeds to a car, tickets to an event, legal documents, signatures etc. One of the earliest examples of a commercial NFT would be a project called Crypto Punks, created by LarvaLabs in 2017. It was a collection of 10,000 uniquely generated 8-bit collectible characters on the blockchain [3]. Even though they are just digital images, they are deemed as an important piece of internet history, and the cheapest Crypto Punk costs over \$100,000 today. It is worth mentioning that depending on their properties and rarity, the prices of Crypto Punks differ, most expensive one in the collection (#5822) was sold for roughly \$24 million. Another example showing the mind-blowing value of NFTs is the work of a famous digital artist, Beeple, whose art piece called "Everydays-The First 5,000 Days" was sold for \$69.5 million in form of an NFT in March 2021 [4]. This craze has attracted attention

of media globally, which resulted in influx of millions of new investors. Arts and collectibles have pushed NFTs into the mainstream, and other categories such as gaming have soon followed the lead. Projects like Crypto Kitties and Axie Infinity have spearheaded the growth of gaming NFT's [5][6]. Slowly but surely, the technology is making its way into other industries as well. In the continuation of the paper, we will be looking at the technological innovations which were used as a foundation for NFTs, and we will be discussing possible future application of NFTs in ticketing, medical, entertainment, business, real estate, and finance industry.

## II. TECHNOLOGICAL FOUNDATIONS OF NFT

### A. Blockchain

The blockchain can be described as a distributed database that maintains a list of all records in blocks of data which are protected and linked to each other using cryptographic protocols. Each transaction is validated by consensus of majority of participants before being grouped into a block and added to the chain. Each block is cryptographically linked to the previous one and replicated across copies of the entire ledger within the network. There is a set of rules established to automatically resolve any possible conflicts. This concept, combined with several other technologies was used by Satoshi Nakamoto in 2008 to propose an idea of peer-to-peer electronic cash, effectively creating Bitcoin [7]. The first of many modern cryptocurrencies. The most widely used blockchain in NFT schemes is Ethereum, while Solana, Binance Smart Chain, Cardano, Algorand and many other blockchains are becoming increasingly popular as well.

### B. Ethereum

The idea for Ethereum was first published by Vitalik Buterin in 2014, setting the foundation for its launch in 2015 [8]. Just like bitcoin, it is using blockchain technology, with Ether (ETH) being its main cryptocurrency. As opposed to bitcoin, Ethereum can execute and run programmable code on its network. To put it simply, it is be-

having like a global and decentralized virtual computer, whose state every participant in the network agrees on. This innovation has made Ethereum the foundation for many emerging technologies, such as DeFi (Decentralized Finance), DAOs (Decentralized Autonomous Organizations) and NFTs. Some of the benefits of Ethereum are: Zero Downtime, Privacy, Resistance to Censorship, Complete data integrity, Trustless Computation [9].

### 1) DeFi (Decentralized Finance)

DeFi is an umbrella term for all financial products and services accessible through Ethereum. With DeFi, there is no centralized authority who can block payments or deny access to anyone. Services like lending, borrowing, token trading and crowdfunding that were previously prone to human errors are now automatic and handled by open-source code that can be inspected and verified by anyone [10].

### 2) DAO (Decentralized Autonomous Organizations)

DAOs are an effective and safe work to create organizations with unknown parties around the world. Simply put, it is an organization collectively owned and managed by its own members. All decisions and proposals are governed by voting, ensuring every member has a voice. There is no central authority, everything is controlled by a publicly available code [11].

### C. Smart Contracts

The concept of smart contracts was first introduced by Nick Szabo in 1996 [12]. Ethereum further developed his idea, applying it onto the blockchain. Essentially, smart contracts are enabling unfamiliar parties to conduct fair exchange and automatically enforce contractual terms of an agreement without need for a third party. In oversimplified terms, as described by Nick Szabo, they can be compared to a vending machine – with the right inputs, a certain output is guaranteed. Just like a vending machine can remove the need for a vendor employee, smart contracts can replace third parties in many different industries.

Anyone can create a smart contract and deploy it on the blockchain, and anyone can interact with the contract if the fee is paid to the network [13]. Ethereum's primary programming language, Solidity, is a Turing complete language, giving a lot of flexibility to developers. Most NFT projects are relying on smart contract-based solutions for implementing sale agreements, verifying ownership, handling transferability, limiting the supply and many other functions.

### D. Address and Transaction

A blockchain based address is consisting of a fixed number of alphanumeric characters. It is used as a unique identifier for users to send and receive assets. In order to transfer any assets on the blockchain, including NFTs, the transactor must prove he is in possession of the corresponding private key and sign the transaction with a correct digital signature. Nowadays, this operation is simplified with the rise of popularity of cryptocurrency wallets such as MetaMask, TrustWallet, Trezor, Ledger Nano and others.

### III. NFT APPLICATIONS

Figure 1 shows a taxonomy of possible NFT applications, dividing it into physical and digital assets.

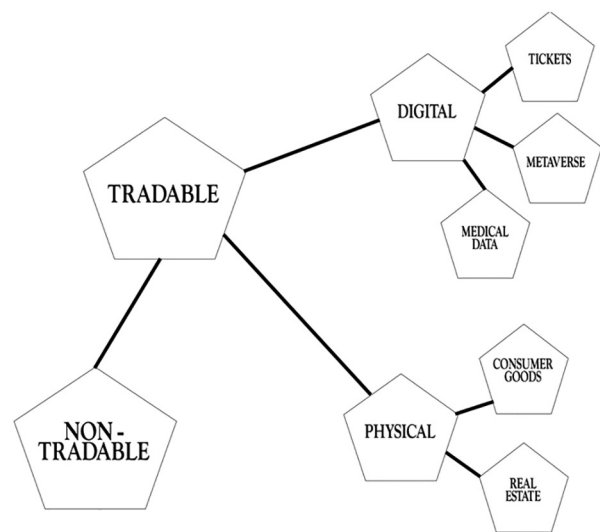


Fig. 1 – Taxonomy of NFT applications

The possibility of identifying ownership of anything on the blockchain is allowing us to trade both digital and physical goods using the NFT technology. This section will explore and discuss possible future applications through several examples. Some of the proposed solutions are already in the works, and some are just theories of what can be done.

#### A. Ticketing

Digitalization of tickets has pushed the entire industry forward, leaving behind many of the problems which were tied to physical tickets, such as: cost of printing and distributing, possibilities of losing or damaging the ticket before the event and many others. New, digital tickets in form of QR codes got rid of these problems, both for the event goers and organizers, still, a lot more can be done to improve the business. Fraud is still very much present in the ticketing industry, a lot of secondhand ticket buyers are prone to scams, there is no way to know whether a ticket they are buying is real, or fake. On the other hand, the organizers do not earn any additional revenue on secondhand sales, while customers must pay much higher

prices, which is a loss for both sides. These problems can be solved by implementing NFT technology. The transfer of tickets from the initial sale, all the way to secondhand sales would be stored on the blockchain immutably, and all parties could prove the tickets authenticity with ease. As a programmable digital asset, NFTs can have built in rules for royalty splits, which means that everyone participating in organization of an event can receive their part of the earning directly from the smart contract, removing the need for unnecessary third parties. Event after the event, tickets would stay as collectibles in the customers crypto wallet, possibly being re-sold to other collectors with ease.

### B. Metaverse

Metaverse is the idea of a perpetual and persistent multiuser virtual environment unifying physical and digital reality. This concept is not necessarily new, in early 2000's, massive multiplayer games such as "Second Life" and "World of Warcraft" were already textbook examples of a Metaverse [14][15]. In case of Second Life, users could create their own content or services and trade with other people. Players could also enjoy many different real-world experiences such as working, partying and even purchasing and renting out virtual properties. The game had its own virtual economy, and virtual currency which could be exchanged with real-world currencies. Even though the idea itself has been around for over 20 years, recent advancements in technologies such as VR (Virtual Reality), AR (Augmented Reality) and MR (Mixed Reality) have brought it to the forefront of tech industry. Rapid development of blockchain technology has created an opportunity to create a new, more appealing type of Metaverse, in which all assets are owned by the players instead of centralized companies. By utilizing NFT technology, ownership of every asset in the virtual world would be easily trackable, and tradable. One of the pioneers a project called Decentraland - it is a virtual reality platform powered by the Ethereum blockchain, in which users can create, experience, and monetize content in applications [16]. Every piece of land in Decentraland is permanently owned by the community through Non-Fungible Tokens acquired by spending an ERC20 token called MANA. Unlike previously mentioned Second Life, Decentraland is not controlled by a centralized organization. No single entity has the power to modify the rules, contents, or economics of their metaverse. A single piece of virtual land in Decentraland currently costs several thousand dollars and is one of the most traded NFTs on OpenSea, with over 185 thousand Ethereum in trade volume (currently worth around 379 million dollars) [17]. Their native token MANA has a market cap of over 2 billion dollars, making it one of the world's top cryptocurrencies [18]. Even though Decentraland is still in early phases of development, based just on the trading volume, it is evident that the idea of a decentralized metaverse is very popular among the public.

### C. Real Estate

NFT technology has a huge potential in tokenizing real world assets. Theoretically, owners could issue a token that represents their property, and this token could be sold to interested buyers, completing the process of transferring the ownership with ease. All the information about the property, including when it was built, who was the first owner, how many times it was sold and for what price would be stored on the blockchain without the possibility of tampering. Another benefit of NFTs could be the fractional ownership of real estate. A single expensive property could be split into several tokens and sold to several different investors who would receive percentage of rental income or capital appreciation upon sale through a DAO. Doing this would require no interaction between the investors, there would be no need for a third party, and it would give more people a chance to invest in the real estate market, potentially increasing its overall liquidity. Token being tied to a real-world valuable asset would open more opportunities for decentralized finance as well. Getting loans without ever going to a bank would be possible through various DeFi applications. The property token could be used as a collateral and locked in a pre-defined smart contract until repaying the pre-set amount. Similar concept of decentralized lending already exists through various platforms such as AAVE, with fungible tokens being accepted as collateral [19].

### D. Authenticity of products

According to a report by the Organization for Economic Cooperation and Development (OECD), trade of fake merchandise accounts for 3.3% of global trade. Majority of the globally counterfeited merchandise consist of wearing apparel, footwear, clothes [20]. These goods are usually much lower-quality products, and their sales hurt the brand identity and company revenue, but they do not impose as big of a threat as fake pharmaceuticals for example. Counterfeit pharmaceuticals and personal care products can jeopardize customers health and safety, and it is very important to find new solutions to fight this problem. As per WHO's estimates, 1 in 10 medical products in low and middle-income countries is substandard or falsified [21]. Various tests have identified drugs containing unhygienic or dangerous materials like brick dust, sheetrock, and printer ink [22]. Merck KGaA has reported that counterfeit antimalarial drugs alone could be responsible for the deaths of up to 155,000 children annually [23]. Pharmaceutical supply chains usually span across multiple different countries, making it very difficult to track and authenticate genuine product. Implementing NFT technology could become a solution for authentication of genuine products. Blockchain technology could allow us to trace the product from its creation to the final destination, without the possibility of tampering with the information or adding more units. Every unit in the starting pharmaceutical factory can be tokenized on the blockchain, containing necessary information such as: Serial Number, Ownership, Name,

Expiration Date, Active Principle, Company Name, Description etc. Only the creator of the smart contract could change the data, and it would be publicly visible. When the package physically leaves the factory and is distributed to the next point in the chain of supply, the ownership of the NFT will be transferred as well, with the transfer being publicly visible on the ledger. Once the final product is sold to the customer, the NFT ownership will be changed to an address which no one has the control of, burning it, so it cannot be sold again. Applying this method, it would be very easy for the customer to check the authenticity of the product they are buying. If for example, they check the information, and see that the product was produced at Factory A, sent to warehouse B, which sent it to pharmacy C, if they encounter the product in any other pharmacy, they can be sure that it is fake. There would be no way to add additional fake products in the middle of the supply chain, as any additionally created product, would not have a valid ID and history dating back to the production factory. Same system could also be used with different type of products, such as luxury goods, electronics, vehicle parts etc.

### E. Medicine

Most medical information is digitized and saved in electronic health records. This data is not used by physicians exclusively, instead, medical researchers and companies are purchasing it in large, anonymized sets as well. While this is very important for the advancements in medical industry, it is also posing an ethical question. Large amounts of sensitive, personal health information are being traded legally, outside of patient's awareness. While the data is anonymized, there is no reason to believe that it cannot be deanonymized using modern computer advancements. According to Kristin Kostick-Quenet, a medical ethicist at Baylor University, the current system is favoring the companies which control access to health records, instead of being centered around the interests of the patients whose data is being used. There is no way for patients to know, if they're data is being sold, how much it is being sold for, or what is it being used for. NFT technology could provide a solution, which would increase the overall transparency and include the patients in the whole process. By tokenizing medical data as an NFT on the blockchain, and by leveraging the possibilities of smart contracts, patients would be able to pre-decide how their data can be used. For example, patients could set a rule, that they are allowing their data to be used for academic research, but not for commercial use. They'd be able to see who requested access to their data, what was it used for, and even get a cut from the sale of their data [24].

## IV. CONCLUSION

NFT is a young, emerging technology which could change the future and reshape the market of digital and physical assets. In years ahead of us, there are many challenges standing in the way of mass adoption. Scalability

and performance are some of them. Most of NFTs are minted on Layer-1 blockchains such as Ethereum, where high gas fees and high network congestion can be an issue. During peak times, a simple mint execution can cost up to 300\$ per NFT. Recently, during the mad rush to mint Otherdeed NFTs, investors have spent approximately \$157 million in gas fees to mint only 55,843 tokens [25]. On average, around \$2800 was spent on fees per each NFT. In addition, current Proof-Of-Work system employed by Ethereum is known to leave a very high carbon footprint, which is problematic for the environment. A single NFT minting equals to around 100 KgCO<sub>2</sub>, with every additional transaction adding up. For example, an NFT which was minted and sold several times could equal to 500 + KGCO<sub>2</sub> which is comparable to pollution of a 5+ hour long flight [26]. Although it won't solve this problem completely, Ethereum's upcoming switch to Proof-Of-Stake will substantially lower the carbon footprint, lower the gas price, and increase transaction speed [27]. Security is also a very important issue – people all over the globe are getting hacked and scammed daily. Usually, in centralized systems, money can be refunded, stolen items can be given back, and passwords can be changed. In a decentralized system, there is no central authority that could help the aggrieved party. Same people losing their Facebook password in phishing email attacks today, could lose their property deed in the same attack tomorrow if nothing is done about security. Currently, only 25% of U.S. adults are familiar with NFT, while only 7% are active users, that is not a surprise, seeing as how complex participation in the market is at the moment [28]. To reach mass adoption, this space needs to adapt a more user-friendly approach. For now, NFTs have revolutionized digital art market, giving artists around the world a new way to monetize their work without restrictions. Time will show whether this technology will mature enough and revolutionize above mentioned industries as well, or it will burst like a bubble many are expecting it to be.

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