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NON-FUNGIBLE TOKEN (NFT) TECHNOLOGY

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Abstract
Non-fungible tokens (NFTs) are a new type of unique and indivisible block chain-based tokens introduced in late 2017. This seminar report addresses this gap in theoretical and practical knowledge and demonstrates the efficacy of NFTs in the domain of event ticketing. It's follow a rigorous design science research approach of designing, building and thoroughly evaluating a prototype of an event ticketing system based on NFTs. Thereby, we demonstrate the usefulness of NFTs to tokenize digital goods, prevent fraud and improve control over secondary market transactions. Further, we contribute generalizable knowledge of the benefits and challenges of NFTs and derive implications for both researchers and practitioners. Finally, this paper proposes managerial recommendations for building applications utilizing NFTs and enables other researchers to draw on its findings and design principles.The concept of NFT originally comes from a token standard of Ethereum, aiming to distinguish each token with distinguishable signs. This type of tokens can be bound with virtual/digital properties as their unique identifications. With NFTs, all marked properties can be freely traded with customized values according to their ages, rarity, liquidity, etc. The thousand fold return on its increasing market draws huge attention worldwide.

Keywords: blockchain, counterfeiting, event ticketing, non-fingible token,

INTRODUCTION

Non-fungible token (NFT) is a way to record, verify, and track the ownership of a unique asset, either physical or digital. Consequently, NFTs can be utilized to represent a work of art, futures contract, music score, book, real estate, etc. – any type of object that could be considered unique or rare. NFTs are minted, stored and transferred on a blockchain, and therefore cannot be seized or tampered with by bad actors. On the other hand, NFTs can provide an instant proof of authenticity and provenance, thus eliminating the problem of counterfeiting. In the first half of 2021, NFT sales rose to a record $2.5 billion.

What is Fungibility?

Before we delve into the intricacies of NFTs, it's worth looking at the difference between "fungible" and "non-fungible." A fungible item or token is, for all intents and purposes, interchangeable with another unit of the same thing. For example, one Bitcoin is equal to another Bitcoin, just like one US dollar is equivalent to another US dollar. If you lend your friend a $10 note, you wouldn't need them to repay the loan with the same $10 note – any $10 note will do.

Things that are non-fungible, on the other hand, are not interchangeable with one another, and have unique properties that can make them radically different from one another, even though they may look similar.

There are many examples of non-fungible items in the real world, such as paintings, concert tickets, and so on. Although two paintings may look similar, they may have drastically different level of rarity. Similarly, front row tickets at a concert are much more valuable than tickets for the back row.

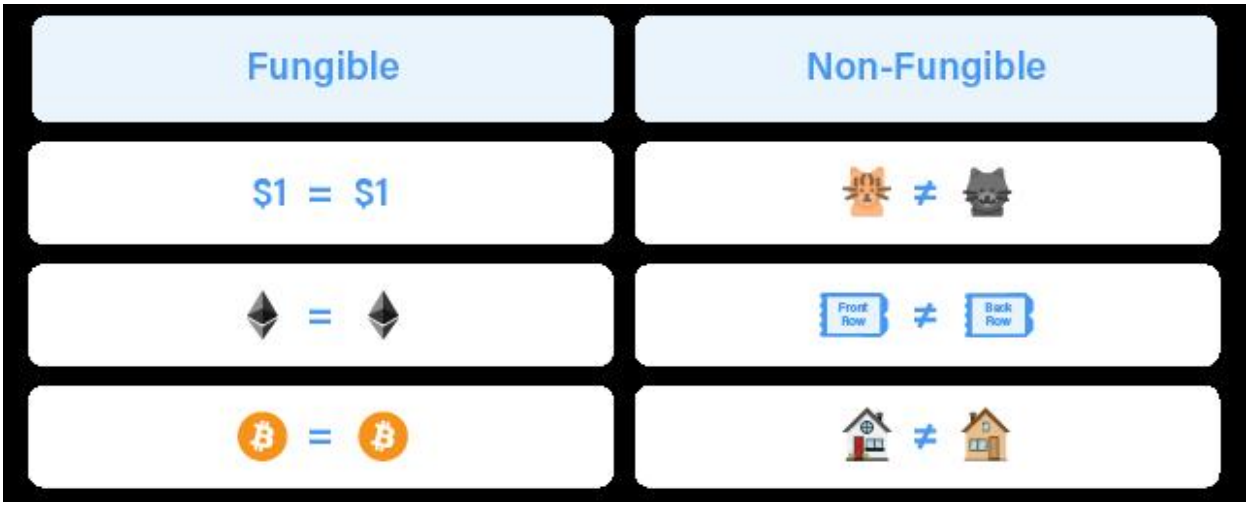

Figure 1.0 Fungible and Non-fungible

However, aside from the existence of first experimental use cases, a deeper understanding of NFTs would be beneficial from the viewpoint of IS research in three main aspects. First, solidified descriptive knowledge about the general characteristics of NFTs and the differences from fungible tokens enables a better understanding of the benefits and resulting opportunities. Second, improved prescriptive knowledge about the process of designing and evaluating applications based on NFTs benefits both researchers and practitioners. Third, increased awareness of practical challenges enables future researchers to better focus on solving remaining challenges. Unfortunately, in-depth investigations of NFTs by academic researchers touching these aspects are still missing. Further, the current body of knowledge lacks best practices, development project experience, and insights to blockchain-based software development (Delmolino et al., 2016). Thus, we conclude that a clear research gap exists.

STATEMENT OF PROBLEM

The world is going more digital every day. Where there is I need to for authentication of digitalproperty like a design picture, not sure of its security can be disturbing, nobody, no one likes his or her property to get stolen even if it is a digital one. In some situation individuals can sell things that are not there property some time to more than one person.

In the world at large were authenticity is a major factor of reducing fraudulent crime not only in digital property but also physical properties. This research is taken to validate the trust worthiness of a system or group of system that can solve them.

AIM OF STUDY

The research aim to present a comprehensive overview of NFT's and its underyling core technologies, namely blockchain and Ethereum and to understand this new technology and to attain that NFTis a financial security consisting of digital data stored in a blockchain, a form of distributed ledger. The ownership of an NFT is recorded in the blockchain, and can be transferred by the owner, allowing NFTs to be sold and traded. NFTs typically contain references to digital files such as photos, videos, and audio. Because NFTs are uniquely identifiable, they differ from cryptocurrencies, which are fungible. The market value of an NFT is associated with the digital file it references.

LITERATURE REVIEW

Historical Background

For the sake of clarity, we've condensed this brief history into a tidy timeline of important events in the history of NFTs, each of these events will also be covered in more detail as we dig deeper into the history of NFTs, further into this article.

NFT Timeline Overview

2012-2016 - The Early History of NFTs

- Coloured Coins
- Kevin McCoy creates the first NFT - Quantum
- Counterparty
- Spells of Genesis
- Memes start being minted as NFTs

2017-2020 - NFTs Go Mainstream

- NFTs Shift to Ethereum
- Token standards introduced
- Cryptopunks
- Cryptokitties
- NFT gaming and Metaverse (Decentraland (MANA)
- Platforms and games with Enjin Coin (ENJ), and Axie Infinity (AXS) surfaced.

2021 - The Year Of The NFT

- Prestigious auction houses start selling NFT art
- Beeple's NFT is sold for a record amount
- Other blockchains start getting involved with their own versions of NFTs (Cardano, Solano, Tezos, Flow, etc)
- A surge in demand for NFTs, especially in the metaverse
- Facebook rebrands as Meta and moves into the metaverse

NFT History Timeline

Here's the timeline of events in the brief history of NFTs in a little more depth.

2012-2016 - The Early History of NFTs

Long before Ethereum existed, the concept that became the driving force of NFTs was already thought up when in 2012, a paper by MeniRosenfield was released that introduced the 'Colored Coins' concept for the Bitcoinblockchain.The idea of Colored Coins was to describe a class of methods for representing and managing real-world assets on the blockchain to prove ownership of those assets; similar to regular Bitcoins, but with an added 'token' element that determines their use, making them segregated and unique.The limitations of Bitcoin meant that the Colored Coins concept could never be realized, however, it did lay the foundation for the experiments that led to the invention of NFTs.

On May 3rd, 2014, digital artist Kevin McCoy minted the first-known NFT 'Quantum' on the Namecoinblockchain. 'Quantum' is a digital image of a pixelated octagon that hypnotically changes colour and pulsates in a manner reminiscent of an octopus.Following these events, a significant amount of experimentation and development occurred and there were platforms built on top of the Bitcoinblockchain. The Ethereumblockchain also started its initial reign over NFTs.The Counterparty platform (Bitcoin 2.0) was established and gained ground as a platform that enabled the creation of digital assets.Spells of Genesis followed close behind in the footsteps of Counterparty and began pioneering in the issuing of in-game assets.

2016 beckoned on the age of the meme and saw the release of a host of Rare Pepes NFTs on the Counterparty platform. Important to note, however, is that the Bitcoinblockchain was never intended to be used as a database for tokens representing the ownership of assets, and thus began the big shift for NFTs to the Ethereumblockchain.

2017-2020 - NFTs Go Mainstream

The big shift for NFTs to Ethereum was backed up with the introduction of a set of token standards, allowing the creation of tokens by developers. The token standard is a subsidiary of the smart contract standard, included to inform developers how to create, issue and deploy new tokens in line with the underlying blockchain technology.

Two software developers; John Watkinson and Matt Hall, followed up the success of the Rare Pepes with their own generative series of NFTs on the Ethereumblockchain which they branded as CryptoPunks. CryptoPunks are considered some of the first NFTs created and originally offered for free. The experimental project, limited to 10,000 pieces with no two characters the same, was inspired by London punk culture and the cyberpunk movement.During the world's largest hackathon for the Ethereum ecosystem, the Vancouver-based venture studio Axiom Zen introduced CryptoKitties.

CryptoKitties is a virtual game based on the Ethereumblockchain, the game enables players to adopt, breed and trade virtual cats, storing them in crypto wallets. After its announcement it wasn't long before the game became a viral sensation, becoming so popular that CryptoKitties clogged the Ethereumblockchain and people began making unbelievable profits. Following the huge success of CryptoKitties, NFT gaming really began to gain momentum and move forward with NFTS gathering increasingly more public attention.

NFT gaming and metaverse projects were in the spotlight and the first to break ground in this space was Decentraland (MANA), a decentralised VR platform on the Ethereumblockchain. Decentraland is an open-world gaming platform that allows players to explore, play games, build, collect items and more, and everything that you find, earn and build there, you own on the blockchain.It wasn't long before other platforms and games using Enjin Coin (ENJ) appeared on the scene, allowing developers to tokenise their in-game items on Ethereum, giving those in-game items a value in the real world. Another blockchain-based trade and battle game also emerged, Axie Infinity (AXS), a game that is partially owned and operated by its players.

2021 - The Year Of The NFT

2021 became the year of the NFT and there was a huge explosion and surge in NFT supply and demand.One of the biggest factors in this boom was the huge changes that occurred within the art market and the industry at large, when prestigious auction houses; Christie's and Sotheby's namely, not only took their auctions into the online world but also began selling NFT art.

This led to Christie's record-breaking sale of Beeple's Everydays: the First 5000 Days NFT for $69 million. Such a huge sale from such a prestigious auction house validated the NFT marketplace significantly. As well as the surge in demand for NFTs that resulted from the famous Christie's auction another knock-on effect was other blockchains getting involved and starting their own versions of NFTs. These included blockchains such as Cardano, Solano, Tezos and Flow. With these newer platforms for NFTs, some new standards were established in order to ensure the authenticity and uniqueness of the digital assets created. Towards the end of the year, once Facebook rebranded as Meta and moved into the metaverse, the surge in NFT demand and especially within the metaverse was remarkable.

THEORETICAL FRAMEWORK

According to Wikipedia, the free encyclopedia A **non-fungible token** (**NFT**) is a financial security consisting of digital data stored in a blockchain, a form of distributed ledger. The ownership of an NFT is recorded in the blockchain, and can be transferred by the owner, allowing NFTs to be sold and traded. NFTs typically contain references to digital files such as photos, videos, and audio. Because NFTs

are uniquely identifiable, they differ from cryptocurrencies, which are fungible. The market value of an NFT is associated with the digital file it references.

Proponents of NFTs claim that NFTs provide a public certificate of authenticity or proof of ownership, but the legal rights conveyed by an NFT can be uncertain. The ownership of an NFT as defined by the blockchain has no inherent legal meaning, and does not necessarily grant copyright, intellectual property rights or other legal rights over its associated digital file. An NFT does not restrict the sharing or copying of its associated digital file, and does not prevent the creation of NFTs that reference identical files.

NFTs have been used as speculative investments, and they have drawn increasing criticism for the energy cost and carbon footprint associated with validating blockchain transactions as well as their frequent use in art scams. The NFT market has also been compared to an economic bubble or a Ponzi scheme.

The NFT market grew dramatically from 2020–2021: the trading of NFTs in 2021 increased to more than $17 billion, up by 21,000% over 2020's total of $82 million.

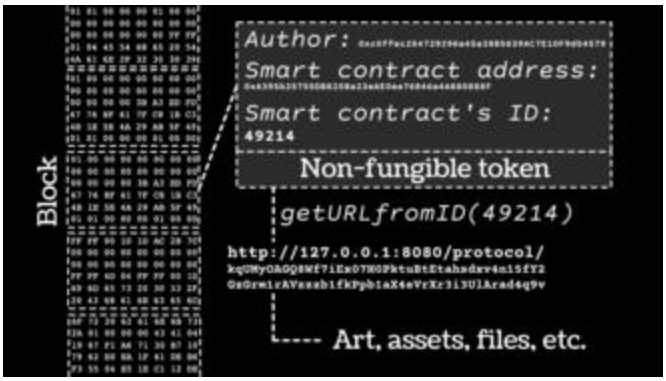

Figure1.1: ***Illustration of a non-fungible token generated by a smart contract***

Characteristics

An NFT is a unit of data, stored on a type of digital ledger called a blockchain, which can be sold and traded.The NFT can be associated with a particular digital or physical asset including but not limited to, art, songs, and sport highlights and a license to use the asset for a specified purpose. An NFT (and, if applicable, the associated license to use, copy, or display the underlying asset) can be traded and sold on digital markets. The extralegal nature of NFT trading usually results in an informal exchange of ownership over the asset that has no legal basis for enforcement, and so often confers little more than use as a status symbol.

NFTs function like cryptographic tokens, but unlike crypto currencies such as Bitcoin or Ethereum, NFTs are not mutually interchangeable, and so are not fungible. (While all bitcoins are equal, each NFT may represent a different underlying asset and thus may have a different value.) NFTs are created when blockchains concatenate records containing cryptographic hashes—sets of characters that identify a set of data—onto previous records, creating a chain of identifiable data blocks. This cryptographic transaction process ensures the authentication of each digital file by providing a digital signature that tracks NFT ownership. Data links that are part of NFT records, which for example may point to details about where the associated art is stored, can be affected by link rot.

Copyright

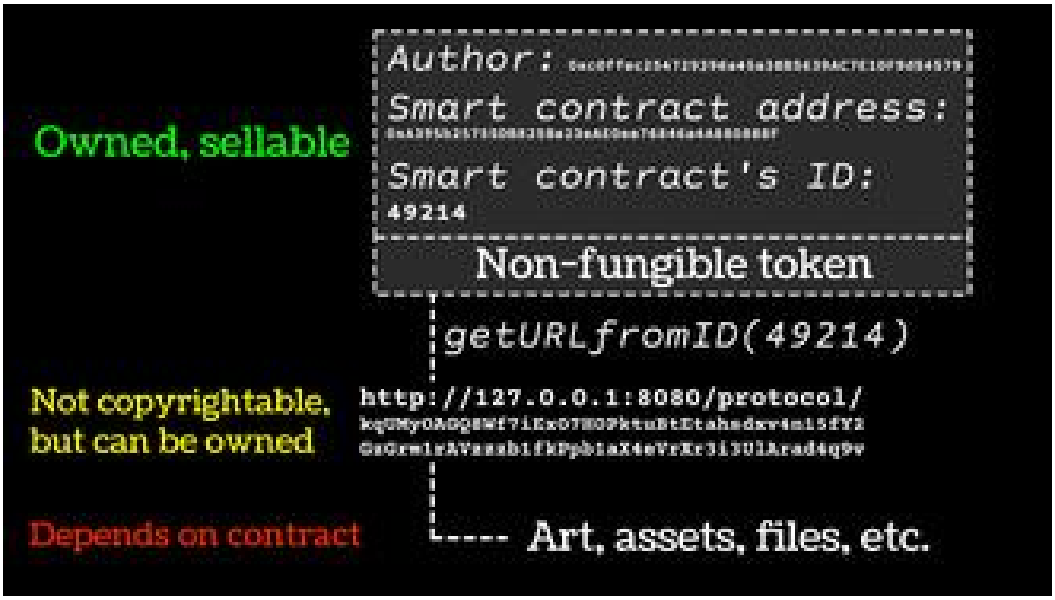

Figure 1.2: diagram showing the right to own of a non-fungible token and linked file.

In most cases, it is heavily dependent on the token's smart contract.Ownership of an NFT does not inherently grant copyright or intellectual property rights to the digital asset the NFT purports to represent. Someone may sell an NFT that represents their work, but the buyer will not necessarily receive copyright to that work, so the seller may create additional NFTs of the same work.So an NFT is merely proof of ownership separate from copyright. According to legal scholar Rebecca Tushnet, "In one sense, the purchaser acquires whatever the art world thinks they have acquired. They definitely do not own the copyright to the underlying work unless it is explicitly transferred.

Unenforceability of copyright

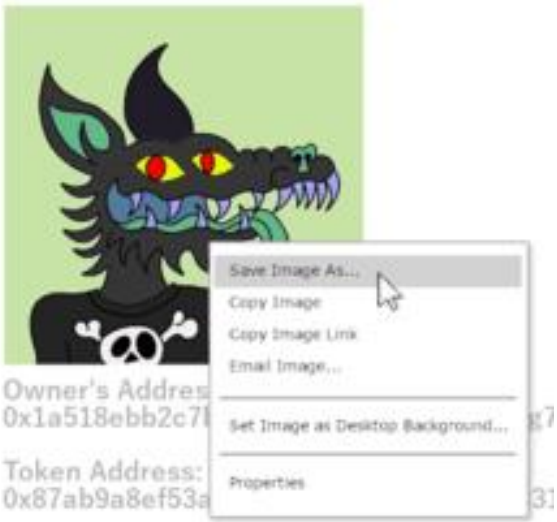

Figure 1.3: Non-fungible token been copied.

As an image on the web, the digital art linked to a non-fungible token may be right-clicked and saved like any other picture file

Because the contents of NFTs are publicly accessible, anybody can easily copy a file referenced by an NFT. Furthermore, the ownership of an NFT on the blockchain does not inherently convey legally enforceable intellectual property rights to the file.

It has become well known that an NFT image can be copied or saved from a web browser by using a right click menu to download the referenced image. NFT supporters disparage this duplication of NFT artwork as "right-clicker mentality". One collector quoted by *Vice* compared the value of a purchased NFT (in contrast

to an unpurchased copy of the underlying asset) to that of a status symbol "to show off that they can afford to pay that much".

The "right-clicker mentality" phrase spread virally after its introduction, particularly among those who were critical of the NFT marketplace and who appropriated the term to flaunt their ability to capture digital art backed by NFT with ease. This criticism was promoted by Australian programmer Geoffrey Huntley who created "The NFT Bay", modeled after The Pirate Bay. The NFT Bay advertised a torrent file purported to contain 19 terabytes of digital art NFT images. Huntley compared his work to an art project from Pauline Pantsdown, and hoped the site would help educate users on what NFTs are and are not.[107] Storage off-chain

NFTs that represent digital art generally do not store the associated artwork file on the blockchain due to the large size of such a file. Such a token functions like a certificate of ownership, with a web address that points to the piece of art in question; this however makes the art itself vulnerable to link rot.

Environmental concerns

NFT purchases and sales are enabled by the high energy usage, and consequent greenhouse gas emissions, associated with blockchain transactions. Though all forms of Ethereum transactions have an impact on the environment, the direct impact of transaction is also dependent upon the size of the Ethereum transaction. The proof-of-work protocol required to regulate and verify blockchain transactions on networks such as Ethereum consumes a large amount of electricity. To estimate the carbon footprint of a given NFT transaction requires a variety of assumptions or estimations about the manner in which that transaction is set up on the blockchain, the economic behavior of blockchain miners (and the energy demands of their mining equipment), and the amount of renewable energy being used on these networks. There are also conceptual questions, such as whether the carbon footprint estimate for an NFT purchase should incorporate some portion of the ongoing energy demand of the underlying network, or just the marginal impact of that particular purchase. An analogy might be the carbon footprint associated with an additional passenger on a given airline flight.

Some NFT technologies use validation protocols such as proof of stake that use much less energy per validation cycle. Other approaches to reducing electricity include the use of off-chain transactions as part of minting an NFT. A number of NFT art sites hope to address these concerns, and some are moving to technologies and protocols with lower associated footprints.[114] Others now allow the option of buying carbon offsets when making NFT purchases, although the environmental benefits of this have been questioned. In some instances, NFT artists have decided against selling some of their own work to limit carbon emission contributions. Though there are now "eco-friendly" NFTs, Ethereum still dominates the NFT market, resulting in an impact on the environment.

Artist and buyer fees

Sales platforms charge artists and buyers fees for minting, listing, claiming, and secondary sales. Analysis of NFT markets in March 2021, in the immediate aftermath of Beeple's "Everydays: the First 5000 Days" selling for US$69.3 million, found that most NFT artworks were selling for less than US$200, with a third selling for less than US$100. Those selling NFTs below $100 were paying platform fees between 72.5% and 157.5% of that amount. On average the fees make 100.5% of the price, meaning that such artists were on average paying more money in fees than they were making in sales.[118]

Plagiarism and fraud

There have been cases of artists having their work sold by others as an NFT, without permission. After the artist Qing Han died in 2020, her identity was assumed by a fraudster and a number of her works became available for purchase as NFTs. Similarly, a seller posing as Banksy succeeded in selling an NFT supposedly made by the artist for $336,000 in 2021; with the seller in this case refunding the money after the case drew media attention. The ease of creating plagiarized NFT works, along with the anonymity of minting NFTs, makes it hard to pursue legal action against NFT plagiarists.

Some NFT marketplaces responded to cases of plagiarism by creating "takedown teams" to respond to artist complaints. The NFT marketplace OpenSea has rules against plagiarism and deepfakes (non-consensual intimate imagery). Some artists criticized OpenSea's efforts, saying they are slow to respond to takedown

requests and that artists are subject to support scams from users who claim to be representatives from the platform. Others argue that there is no market incentive for NFT marketplaces to crack down on plagiarism.

- A process known as "sleepminting" allows a fraudster to mint an NFT in an artist's wallet and transfer it back to their own account without the artist becoming aware. This allowed a white hat hacker to mint a fraudulent NFT that had seemingly originated from the wallet of the artist Beeple.
- Plagiarism concerns led the art website DeviantArt to create a bot that searches and compares user art to art on popular NFT marketplaces. If the bot finds art that is similar, it warns the user and instructs the user how they can contact NFT marketplaces to request that they take down their plagiarized work.
- The BBC reported a case of insider trading when an employee of the NFT marketplace OpenSea bought specific NFTs before they were launched, with prior knowledge those NFTs would be promoted on the company's home page. NFT trading is an unregulated market in which there is no legal recourse for such abuses.
- When Adobe announced they were adding NFT support to their graphics editor Photoshop, the company proposed creating an InterPlanetary File System database as an alternative means of establishing authenticity for digital works.
- The price paid for specific NFTs and the sales volume of a particular NFT author may be artificially inflated by wash trading, which is prevalent due to a lack of government regulation on NFTs.

Security

In January 2022, it was reported that some NFTs were being exploited by sellers to unknowingly gather user IP addresses.

Uses

Commonly associated files

NFTs have been used to exchange digital tokens that link to a digital file asset. Ownership of an NFT is often associated with a license to use such a linked digital asset, but generally does not confer copyright to the buyer. Some agreements only grant a license for personal, non-commercial use, while other licenses also allow commercial use of the underlying digital asset.

Digital art

Digital art is a common use case for NFTs.High-profile auctions of NFTs linked to digital art have received considerable public attention. The work entitled *Merge* by artist Pak was the most expensive NFT, with an auction price of US$91.8 million and *Everydays: the First 5000 Days*, by artist Mike Winkelmann (known professionally as Beeple) the second most expensive at US$69.3 million in 2021.

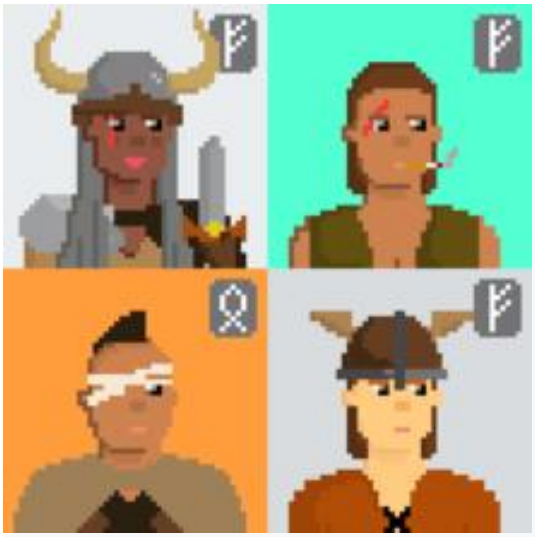

Figure 1.4: Some digital art NFTs, like these pixel art characters.

Some NFT collections, including Bored Apes, EtherRocks and CryptoPunks are examples of generative art, where many different images are created by assembling a selection of simple picture components in different combinations.

In March 2021, the blockchain company Injective Protocol bought a $95,000 original screen print entitled *Morons (White)* from English graffiti artist Banksy, and filmed somebody burning it with a cigarette lighter. They mintedand sold the video as an NFT. The person who destroyed the artwork, who called themselves "Burnt Banksy", described the act as a way to transfer a physical work of art to the NFT space.[41]

American curator and art historian Tina Rivers Ryan, who specializes in digital works, said that art museums are widely not convinced that NFTs have "lasting cultural relevance."[42] Ryan compares NFTs to the net art fad before the dot-com bubble.[43] No centralized means of authentication exists to prevent stolen and counterfeit digital works from being sold as NFTs, although auction houses like Sotheby's, Christie's, and various museums and galleries worldwide started collaborations and partnerships with digital artists such as RefikAnadol, Dangiuz and Sarah Zucker, selling NFTs associated with digital artworks (via NFT platforms) and showcasing those artworks (associated with the respective NFTs) both in virtual galleries and real life screens, monitors, and TVs.[44][45]

Games

Blockchain game

NFTs can represent in-game assets, such as digital plots of land. Some commentators describe these as being controlled "by the user" instead of the game developer[46] if they can be traded on third-party marketplaces without permission from the game developer.[47]

- CryptoKitties was an early successful blockchain online game in which players adopt and trade virtual cats. The monetization of NFTs within the game raised a $12.5 million investment, with some kitties selling for over $100,000 each.[27][48] Following its success, CryptoKitties was added to the ERC-721 standard, which was created in January 2018 (and finalized in June).[49][23] A similar NFT-based online game, Axie Infinity, was launched in March 2018.
- In October 2021, Valve Corporation banned applications from their Steam platform if those applications use blockchain technology or NFTs to exchange value or game artifacts.[50]
- In December 2021, Ubisoft announced Ubisoft Quartz, "an NFT initiative which allows people to buy artificially scarce digital items using cryptocurrency". The announcement prompted criticism, with a dislike ratio of 96% over the YouTube announcement video, which has since been unlisted.[51] Some Ubisoft developers also raised their concern[*clarification needed*] over the announcement.[52] The Game Developers Conference's 2022 annual report stated that 70 percent of developers surveyed said their studios had no interest in integrating NFTs or cryptocurrency into their games.[53]
- Some luxury brands minted NFTs for online video game cosmetics.[54] In November 2021, Morgan Stanley published a note suggesting that this use could become a multi-billion dollar market by 2030.[55]

Music

In February 2021, NFTs reportedly generated around US$25 million in the music industry, with artists selling artwork and music as NFT tokens.[56] On February 28, 2021, electronic dance musician 3LAU sold a collection of 33 NFTs for a total of US$11.7 million to commemorate the three-year anniversary of his *Ultraviolet* album.[57][58] On March 3, 2021, an NFT was made to promote the Kings of Leon album *When You See Yourself*.[59] Other musicians who have used NFTs include American rapper Lil Pump,[60][61][62] Grimes,[63] visual artist Shepard Fairey in collaboration with record producer Mike Dean,[64] and rapper Eminem.[65]

Film

- In May 2018, 20th Century Fox partnered with Atom Tickets and released limited-edition *Deadpool 2* digital posters to promote the film. They were available from OpenSea and the GFT exchange.[66] In March 2021 Adam Benzine's 2015 documentary *Claude Lanzmann: Spectres of the Shoah* became the first motion picture and documentary film to be auctioned as an NFT.[67]

- Other projects in the film industry using NFTs include the announcement that an exclusive NFT artwork collection will be released for *Godzilla vs. Kong*[68] and director Kevin Smith announcing in April 2021 that his forthcoming horror movie *Killroy Was Here* would be released as an NFT.[69] The 2021 film *Zero Contact*, directed by Rick Dugdale and starring Anthony Hopkins, was also released as an NFT.[70]
- In April 2021, an NFT associated with the score of the movie *Triumph*, composed by Gregg Leonard, was the first NFT minted for a feature film score.[71]
- In November 2021, film director Quentin Tarantino released seven NFTs based on uncut scenes of *Pulp Fiction*. Miramax subsequently filed a lawsuit claiming that their film rights were violated and that the original 1993 contract with Tarantino gave them the right to mint NFTs in relation to *Pulp Fiction*.

MATERIALS AND EXPERIMENT

Financialization of the NFT

In this section, we provide a brief overview of the NFT financialization processes as well as profit opportunities NFTs generate for institutions, retail investors, creators, and network end-users. The section concludes with a discussion of the proposed extensions to the existing NFT usability and the NFT wealth management.

NFT transformation of the existing asset classes

Arguably, most of the investable assets available in private and public markets are non-fungible.

For instance, the estimated value of real-estate - which by nature is non-fungible - far exceeds the capitalizations of both the global bond and equity markets5. Perhaps more important, the derivatives, which are the largest asset class with the notional value of $580 trillion6, are non-fungible as well 7. They cannot be transferred between different exchanges and trading systems. Obviously, art and collectibles are another group of non-fungible assets, albeit with significantly lower value (about $2trillion8). Interestingly, ADRs are not fungible either. Non-US investors cannot trade ADRs in their home markets on par with domestic stocks (Bacidore and Sofianos, 2002).

The above discussion and advances in existing technology imply that all non-fungible assets can be represented as NFTs. Exploring this possibility is critically important for a number of reasons. First, NFTs improve market liquidity and price discovery. It is more efficient to trade assets, if the ownership can be instantaneously proven and transferred quickly and securely for a near-zero fee. That way, NFTs increase openness, transparency, and financial globalization of the assets. In and of itself, this leads to higher trading volumes and market expansion. Second, NFTs eliminate delayed clearance and settlement functions. At present, settlement lag can be counted in days (Duffie, Garleanu, and Pedersen, 2002). NFTs shorten settlement process from days to seconds. Moreover, Covitz and Downing (2007) report that some market participants still use physical clearance. Instark contrast, NFTs use fraud-proof blockchains, where information can be verified and recordedinstantaneously. Third, collateral management requires transparency, which in the existing financial system can be seriously compromised as in the recent case of e.g., Archegos9. Here again, the NFT provides a clear-cut solution, where market participants have no opportunity to camouflage self-serving behaviors.

NFT minting, trading, and auctioning

Presently, the most prevalent use case for NFT is artwork and in-game items .One might expect this to be so because NFT architecture allows for the removal of the intermediary between the creator and the public, thus increasing the product outreach, profit margin, and sales potential. It is well known that in the artworld, there still exist gatekeepers that limit creators' access to the marketplace. These include exclusive venues, elite groups, and rent-extracting middlemen. The NFTs allow for circumventing the traditional gatekeepers in the art world. Notably, the creators are able to generate (mint) the NFT of their art piece or the entire art collection on the blockchainusing either the existing on-line marketplaces (e.g., OpenSea, Rarible) or decentralized applications that directly connect them to the desired network. One need not be expert to be able to mint an NFT, a process that removes entry barriers to the primary and secondary art markets. Going

further, minting an NFT appears to be synonymous with marketing an NFT, either at an arbitrary fixed-price or through various auction mechanisms.

A related issue concerns the rights sold together with the NFT. The existing standards remain flexible. For example, the current owner of the most expensive NFT to date,"Everyday: The First 500 Days" by Beeple, which sold for 69.3 ($mil), acquired the right to display the NFT but not the copyrights. On the other hand, owners of the Hashmasks NFTs (there are 16,384 unique ones) acquire unlimited rights to use, copy, and display the NFT. Awkwardly, the NFT of the tungsten cube sold on OpenSea grants its holder the right to"one visit to see/photograph/touch the cube per calendar year."

NFT liquidity mining and NFT farming

NFT liquidity mining and NFT farming are closely related concepts. NFT liquidity mining is an Investment activity that involves locking an NFT in a smart contract with two main objectives depending on the market side: 1) creating NFT deposits (providing liquidity) on the NFT platform, and 2) generating a profit for the NFT investor for making the NFT deposit. Similar to a simplebuy-and-hold strategy, NFT liquidity mining requires creating or purchasing an NFT and sending it to a smart contract (akin to staking activity in the PoSblockchain). In return for providing NFT liquidity, investor receives interest. Interest payment is typically denominated in a native currency of the network that relies on NFT liquidity mining for survival. It should be emphasized, that mining programs could arguably amass greater liquidity, if NFTs are fractionalized and therefore directly interchangeable. For example, Dego Finance (DEGO) is the NFT-related project that focuses on NFT mining, auctioning, trading, farming, and other diverse NFT applications. Dego pays NFT owners for depositing their NFTs in the native Dego token with voting and dividend rights attached. The yield on staking is determined by the mining efficiency and power value attributed to a given NFT.

NFT farming, on the other hand, involves staking blockchain native token with the aim of receiving a native NFT as a reward, which then could be held, sold or used as collateral. NFT farming is currently operational on some of the NFT-dedicated blockchains (e.g., Ethernity, SuperFarm). It is worth noting that the locked native token can be un-farmed at any time.

NFT collateral-based loans

NFT holders may wish to unlock liquidity using collateralized loans against the value of their NFTs. The freed-up resources could then be used for investment, charity, consumption and more. Similar to existing lending protocols in DeFi, NFTs market valuation can be determined algorithmically in a smart contract. Conversely, investors may wish to borrow an NFT with the objective to generate yield. Paribus (PBX) is one of the protocols at the forefront of the NFT borrowing and lending. Another startup, Yield Guild Games (YGG) operates as an NFT holding firm and lends out NFTs to blockchain-based game players for a fee.

Fractional NFT

Unlike accredited investors and investment funds, retail clientele has limited access to capital, which narrows their investment opportunity set. On the other hand, certain asset classes experience low liquidity and unbalanced markets due to their prohibitive price levels. Blockchain technology solves the above problems by allowing for fractionalization of assets that is, breaking up the asset into a number of smaller pieces. This possibility has already been discussed in the literature in the context of artwork under the name of securitization (Mei and Moses, 2002).

NFT fractionalization enables investors to purchase a piece of the NFT. It therefore representsthe opportunity to get exposure to expensive and renowned NFT with high absolute price levels. For example, in a recent auction at Christie's, an NFT by a contemporary artist Mike Winkelmann(aka Beeple) sold for 69($mil) – an auction price out of reach for retail investors, fans, and small collectors. Fractionalization also ensures greater diversification potential. A piece of NFT can thus improve portfolio efficiency i.e., its alpha for a given level of risk. The work of art can be minted as NFT, however, once it is split into multiple parts, each of these parts might be represented by a fungible token, that is a token which is perfectly interchangeable with other parts of the same NFT. Conversely, an NFT can be fractionalized into multiple NFT of different distinctive features and thus distinct valuations, and remain non-fungible. For example, a collector may be willing to pay more for Mona Lisa's shard of lips than for a shard of background 8

landscape from the same painting. In any case, many different collectors can now own pieces of exactly the same artwork, a possibility that never existed before in history.

Fractional NFT can be further endowed. It can be envisaged that owners of the fractional NFTs pool them together to create a decentralized autonomous organization (DAO) and issue shares against that endowment. The example suggests endless possibilities opened up by tokenization of unique assets.

EXPERIMENTAL METHOD

To design, implement and evaluate a blockchain event ticketing system prototype, we follow a DSR approach. DSR, which historically originated from engineering, involves the creation of an artifact which has not existed previously and serves a meaningful human purpose (March and Smith, 1995). Typical characteristics of such research efforts are strong reliance on creativity and trial-and-error search (Hevner et al., 2004). In the DSR context, the creation of a prototype depicts an instantiation of a blockchain-based IT artifact (March and Smith, 1995). Through artifact instantiation, we demonstrate both feasibility of the design process and the designed product and enable researchers to learn about the effect of the artifact on the real world and appropriate use (Hevner et al., 2004). This approach has been taken several times by IS researchers when dealing with new aspects of blockchain technology (Beck et al., 2016; Notheisen et al., 2017; Schweizer et al., 2017).

Hevner et al. (2004) list seven guidelines for applying DSR in the IS space: It requires the creation of an innovative artifact that fulfills a specific purpose for a specified problem domain. It is crucial to thoroughly evaluate the artifact with respect to providing a solution to the specified problem. A clear and verifiable contribution such as solving an unsolved problem or solving a known problem in a more effective or efficient manner is also mandatory. It requires rigorous definition, formal representation, coherence, and internal consistency of the artifact. Through the creation of the artifact, we construct a problem space along the process and a method to find an effective solution for it. Finally, we must communicate the results effectively. In Table 1, we map our approach to meet these seven guidelines.

Table 1.0: Mapping of DSR Guidelines by Hevner et al. (2004) and our Contributions

GUIDELINE	CONTRIBUTION
Design as an artifact	The prototype we build during our research instantiates an NFT-based artifact that allows trust-free creation, management and transactions of event tickets.
Problem relevance	We address a research gap in scientific literature regarding the question whether NFTs are suited to represent scarce digital assets (such as event tickets) and additionally try to gain insight into the benefits and challenges of the use of NFTs, which are yet to be determined by researchers. Regarding the use case of event tickets, we aim to address the problems of fraud, lack of trust, lack of control over secondary market transactions, low transparency and high dependence on intermediaries.
Design evaluation	To evaluate the prototype in terms of functionality, formal completeness, consistency, accuracy, reliability and efficiency, we follow the approach of Hevner et al., 2004, who state that the first and foremost aim is to show that (1) the solution works (proof by construction) and (2) characterize the environments in which it works (illustrative scenarios).
Research contributions	Our contribution is to demonstrate the usefulness of NFTs in the domain of event tickets in scientific rigor. Through artifact instantiation, we demonstrate both feasibility of the design process and the designed product and enable researchers to learn about the effect of the artifact on the real world and appropriate use (Hevner et al., 2004). Additionally, we aim to lay ground for further research and higher-theory in the area of NFTs and blockchain-based application development (Gregor, 2006; Glaser, 2017).
Research rigor	As this table shows, we closely follow the guidelines by Hevner et al., 2004 regarding the DSR process in IS. Additionally, we draw on best practices by other IS researchers that have dealt with similar approaches when evaluating new aspects of blockchain technology (Beck et al., 2016; Notheisen et al., 2017; Schweitzer et al., 2017). To determine if our artifact design is complete, we follow a strategy of satisficing, meaning the solution is satisfactory regarding solving the requirements and constraints of the problem we state for the selected use case (Hevner et al.,

	2004).
Design as search process	We follow an iterative build and evaluate approach. To further assess suitability of the artifact to its intended purpose and gain insights into the benefits and challenges, we additionally draw on extant literature on both the application and solution domain as suggested by Hevner et al. (2004) and perform semi-structured expert interviews (Schultze and Avital, 2011). As peer-reviewed literature is scarce in this new area of research, we also make use of publicly accessible Internet sources such as open-source code repositories, whitepapers and blog articles, which strengthen our domain knowledge and ensure the regency of this paper.
Communication of research	We aim to provide clear information to both the management-oriented and technically-oriented audiences. The former benefits by the schematic UML diagram and theoretical reasoning about benefits and challenges, while for the latter we publish the entire source code of the project on GitHub, including all formal tests. This enables technical researchers and practitioners to replicate our work and/or build on it.

Prototype Design and Development

In this section, we present the design and development of our blockchain-based event ticketing system according to the DSR guidelines by Hevner et al. (2004). First, we briefly outline the verified problem statement and the design objectives for the prototype. Second, we elaborate the fundamental design decision that led to the choice of the Ethereumblockchain and NFTs as core component of the prototype. Finally, we present an overview of the resulting prototype design and briefly explain its application.

CHALLENGES

Our literature analysis revealed the current problems in the event ticketing industry. To recap our findings, the status quo is not satisfactory for the two central stakeholders – the event organizer and the attendee, as multiple complaints at consumer protection agencies show (McMillan, 2016; Courty, 2017; NZ Herald, 2017). Following the relevance cycle laid out by Hevner (2007), we additionally validated our findings by interviewing the CEO of a ticketing firm, who contributed valuable expert knowledge. He largely confirmed our preliminary findings and added that it would be desirable for event organizers to directly interact with event attendees rather than the need to rely on intermediaries for trust and that an open protocol would be preferable over the opaque status quo. Table 2 gives a brief summary of the identified main problem areas.

Table 1.1: Overview of Identified Problem Areas

Problem area	Description
Lack of Trust	Consumers have to trust third parties when buying tickets on secondary markets and thus face the risk of purchasing fraudulent or invalidated tickets, that face the risk of being cancelled or are counterfeits (The Australian Government the Treasury, 2017).
No control over secondary market prices	Consumer's ticket prices on secondary markets are taken to extremes, partially through the use of bots which automatically drive up prices to earn a profit by reselling them at the highest possible markups (Courty, 2017). From the event organizer's point of view, a major problem is the limited control over secondary transactions.
Dependence on intermediaries	Event organizers are dependent on intermediaries and bear financial risks while being cut off from windfall profits and direct relations with event attendees.
No immediate validation	Attendees cannot easily verify if their tickets are valid (Tackmann, 2017).
Lack of Transparency	A lack of transparency in the secondary market is evident in the event ticketing industry (Waterson, 2016)

Summary

Summing up, NFTs enable new beneficial ways to digitally represent digital and physical assets. Yet, many challenges remain to be solved. NFTs are based on blockchain technology which is still in its infancy and not yet ready for a mass market of retail users, who demand simplicity, user-friendly interfaces and legal clarity. These demands cannot be solved by NFTs but need to be addressed on the level of the underlying blockchain protocols and legal institutions. Further, public knowledge about NFTs is still scarce. For these challenges, we expect its role to be restricted to a backend component rather than being directly visible for retail users. Nonetheless, we consider NFTs a highly valuable component for blockchain-based systems with the potential to enable many more practical use cases apart from the one discussed in this paper.

Conclusion

NFTs are built on blockchain technology, specifically Ethereum, thereby making it transparent, traceable, and secure. The novel characteristic of unique tokens enabled use cases that had not been demonstrated before such as the exclusive ownership of digital assets. The ownership of each asset is traceable which results in enhanced authenticity. The idea of having complete ownership of an authentic, purchased digital asset e.g., images, gifs, videos, music etc. intrigued art collectors and enthusiasts that led to a sudden growth in its market. NFTs are not only limited to digital assets but can also be applied to physical artistic works, allowing the exchange of physical assets similar to their digital counterparts. Numerous platforms facilitate the buying and selling of NFTs, comprising media of varied nature. Moreover, its use extended to many other domains namely education where NFTs are applied to licenses and certification, fashion where it is used to distinguish each article, sports where a new means of revenue generation through basketball card NFTs is devised and so on. The increasing widespread use of NFTs, however, comes with many challenges including lack of industry-wide security standards for smart contracts, uncertainty of intellectual property rights, fraud risks by means of artist impersonation, transparency that violates user security and privacy and drastic adverse environmental effects due to large amount of energy consumption. There exist viable solutions for many of these challenges like the use of zero-knowledge proofs (ZKP) for improved privacy, non-browser wallets for enhanced protection of the crypto assets and migration of blockchain development to more sustainable platforms such as SolarCoin and BitGreen. These solutions are yet to gain momentum among the wider blockchain community, so the challenges persist and remain yet to be addressed effectively in lieu of the massive potential of the NFTs, the marketplace for which is growing rapidly.

Recommendation

The researchers recommend NFT as a good source of investment, because of its ability to generate an income greater than the capital income. It also provides security for digital goods.

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