NON-FUNGIBLE TOKENS: USE CASES OF NFTS AND FUTURE RESEARCH AGENDA

Phil Gonserkewitz [*], Erik Karger [**], Marvin Jagals [*]

* Chair of Information Systems and Strategic IT Management, University of Duisburg-Essen, Essen, Germany
** *Corresponding author*, Chair of Information Systems and Strategic IT Management, University of Duisburg-Essen, Essen, Germany
Contact details: Chair of Information Systems and Strategic IT Management, University of Duisburg-Essen, Universitätsstraße 9, 45141 Essen, Germany

OPEN ACCESS

How to cite this paper:
Gonserkewitz, P., Karger, E., & Jagals, M. (2022). Non-fungible tokens: Use cases of NFTs and future research agenda. *Risk Governance and Control: Financial Markets & Institutions, 12*(3), 8–18. https://doi.org/10.22495/rgcv12i3p1

ISSN Online: 2077-4303
ISSN Print: 2077-429X

Received: 28.07.2022
Accepted: 12.09.2022

JEL Classification: M15, O30, O32
DOI: 10.22495/rgcv12i3p1

Abstract

Blockchain is a disruptive technology that is applied in many different areas (Atici, 2022). Non-fungible tokens (NFTs) are becoming increasingly popular and are already widely used in practice. New use cases for NFTs are emerging all the time. Due to the fact that they are unique, NFTs can prevent counterfeiting, as each token contains the digital signature of the owner (Rehman, Zainab, Imran, & Bawany, 2021). For the use of NFTs to advance in the institutional setting, the opportunities for using NFTs need to be clearly explored. Based on a systematic literature review (SLR), this paper describes and lists the most discussed use cases for NFTs in the scientific literature. The most discussed use cases are art and collectibles, video games, and applications in the metaverse. Another contribution of this article is a future research agenda that contains open questions in the field of NFTs. It aims to provide researchers with promising research avenues to stimulate future research. The results show that there are still challenges in the field of NFT that need to be further explored. In summary, our article aims to equip both researchers and practitioners with an initial overview and knowledge about NFTs, including their applications and challenges.

Keywords: Blockchain, Distributed Ledger, Non-Fungible Token, Digitalization, Decentralization

Authors' individual contribution: Conceptualization — P.G.; Methodology — P.G.; Validation — E.K.; Formal Analysis — P.G.; Investigation — P.G.; Resources — P.G.; Data Curation — P.G.; Writing — Original Draft — P.G.; Writing — Review & Editing — E.K. and M.J.; Visualization — P.G.; Supervision — E.K.; Project Administration — E.K.

Declaration of conflicting interests: The Authors declare that there is no conflict of interest.

Acknowledgements: We acknowledge support by the Open Access Publication Fund of the University of Duisburg-Essen.

1. INTRODUCTION

Nowadays, blockchain solutions are increasingly used, for example, in use cases like fintech, insurance, or supply chain management (Atici, 2022; Siddiqui & Rivera, 2022). The invention of the technology can be dated back to the publication of the Bitcoin whitepaper by Nakamoto (2008). Since then, blockchain platforms have become widely accessible. Given that, there has been a significant increase in interest from software development companies and customers. Blockchains have created many technical opportunities, including non-fungible tokens (NFTs).

In recent years, NFTs have become increasingly popular, both in the scientific field as well as in the industry. The NFT trend did not start until February 2021, and prior to that, there was very low interest, as can be seen from Google Trends[1]. With the help of a blockchain, digital objects can be kept scarce, although they can be copied infinitely (Franceschet, 2021). In practice, NFTs have been

[1] https://trends.google.com/trends/explore?date=today%205-y&q=NFT

used for some time. For example, NFTs can be relevant for artists because they can help to sell artworks digitally (Chalmers, Fisch, Matthews, Quinn, & Recker, 2022). The artist *Beeple*, for example, has caused a particular sensation by selling digital art as an NFT for $69,346,250[2]. NFTs are a fast-moving field with new developments and use cases constantly emerging. However, technological progress and its rapid growth are accompanied by increased security risks, including those related to authenticity. The uniqueness of NFTs can largely prevent counterfeiting, as each token contains a digital signature of the owner (Rehman, Zainab, Imran, & Bawany, 2021). The introduction of NFTs has created new business opportunities for markets that previously had difficulties with digital sales due to a lack of exclusive ownership (Mani, Verma, & Marwaha, 2021).

Many companies today are not even aware of NFTs and the potential benefits that NFTs can have. Additionally, for the broader use of NFTs, existing problems must be addressed. Furthermore, companies need to be educated about the potential use cases of NFTs, including the possibilities of the technology presented. For the use of NFTs to move forward in the institutional sector, the opportunities for NFT use must be clearly explored. For this reason, we aim to provide an overview of the most frequent use cases of NFTs in both practice and research. To do so, the first goal of this article is, therefore, to answer the following research question:

RQ1: What use cases of NFTs are described in the scientific literature?

An iterative systematic literature review (SLR) is conducted to answer the first research question. Through a literature review, the existing scientific literature is systematically identified, collected, analyzed, and summarized, which captures state of the art in a given field. An initial literature search has produced an overview of use cases. Due to low literature availability and to make sure to not miss relevant publications, additional literature searches were conducted for each of the use cases found.

Apart from giving an overview and presenting the state of the art, we believe that a SLR can and should serve as a foundation and platform for future research (Paul & Criado, 2020). Given that, we set the following research question as the second goal for this article:

RQ2: What are possible future research inquiries in the field of NFTs and their use cases?

The remainder of this article is structured as follows. With the introduction, this work consists of six sections. Section 2 covers the foundations of blockchain as well as NFTs. Section 3 deals with the research method used for this article, namely an explanation of the iterative SLR. Section 4 presents the results of the literature review and the identified NFT use cases. In addition, possible future NFT use cases are presented. Also, the problems in the NFT area are addressed, and a future research agenda shows open questions. The penultimate Section 5 contains the discussion in which the research questions are answered, and practical and theoretical implications are discussed. The last Section 6 provides a brief summary of this article, as well as a description of the limitations.

[2] https://onlineonly.christies.com/s/first-open-beeple/beeple-b-1981-1/112924

2. CONCEPTUAL FOUNDATIONS

2.1. Blockchain basics

Recently, the topic of blockchain has been receiving more and more attention. Simply put, a blockchain is a database that anyone can use, but no one can compromise (Valeonti et al., 2021). While in a centralized system, the owner can arbitrarily delete objects, a blockchain is immutable due to decentralization (Chauhan, Malviya, Verma, & Mor, 2018). Each participant in the blockchain makes his or her computer available to ensure decentralization. The computers of the participants are called nodes, and all nodes need a copy of the transaction list (Arya, Kumar, Singh, Mishra, & Chong, 2021). The transaction list is stored on all nodes so that it can be restored in case of problems to guarantee persistence (Golosova & Romanovs, 2018). Once a transaction has been made on the blockchain, it cannot be reversed or deleted.

To execute transactions on the blockchain, a wallet is required. A wallet can be described as a kind of digital purse. No personal data is required to generate the wallet, which creates anonymity. When the wallet is created, a unique wallet address is generated, which is required to receive digital assets (Gatteschi, Lamberti, Demartini, Pranteda, & Santamaría, 2018).

Any user can view the transaction list, which supports the security of the blockchain. Transactions are stored consistently, which means that transactions that have already been executed do not have to be verified again (Arya et al., 2021). Transactions are almost executed in real-time and written directly to the blockchain (Liu, Wu, & Xu, 2019). The actual time of execution depends on the individual blockchain, which is made up of several factors, such as the consensus mechanism.

As the name suggests, the blockchain can be understood as a set of chained blocks. Each of these blocks contains three components: data, hash, and a pointer to the previous hash. The data contained can include different information depending on the purpose of the blockchain. A block's hash value is a unique identifier. The pointer to the previous block links the blocks together and creates a chain, which means that the data cannot be changed afterward. If someone were to change a block, then all subsequent blocks would also be invalid, which would trigger a chain reaction (Chauhan et al., 2018).

In recent years, the popularity of blockchains has increased significantly. A global consulting and research organization predicts strong development, forecasting $176 billion in blockchain-generated value in 2025 and $3.1 trillion in 2030 (Kandaswamy, Furlonger, & Stevens, 2022). The banking sector is one example where blockchain is increasingly applied. Here, blockchain solutions are used for exchanging goods, services, and legal bonds between individuals and institutions (Tasca & Tessone, 2019). This has reduced operational costs for banks. The public sector is increasingly relying on blockchains to drive the transformation to the smart city. In healthcare management, blockchain can monitor people through technology, and automated smart contracts support the collection of needed data while protecting user privacy through blockchain (Mohanta, Panda, &

Jena, 2018). Using a blockchain can support a solution for use cases such as voting systems, Internet of Things (IoT) applications, and supply chain management (Saraf & Sabadra, 2018). Also, blockchain-based solutions are increasingly used in the context of data management, for example, to enable interorganizational data governance or to manage and store training data for artificial intelligence (AI) systems (Karger, Jagals, & Ahlemann, 2021; Jagals, Karger, Ahlemann, & Brée, 2021).

One of the most well-known blockchains is Bitcoin. The Bitcoin network is an electronic peer-to-peer payment system that does not require any third-party providers (Saraf & Sabadra, 2018). Nakamoto (2008) first introduced cryptographic proof as a security mechanism with the publication of the Bitcoin white paper. The consensus mechanism "Proof of Work" is used for this purpose, which guarantees the security of the blockchain (Nakamoto, 2008). According to Statista (2022), Bitcoin transactions are steadily increasing, and by the end of June 2022, over 745 million transactions have been made.

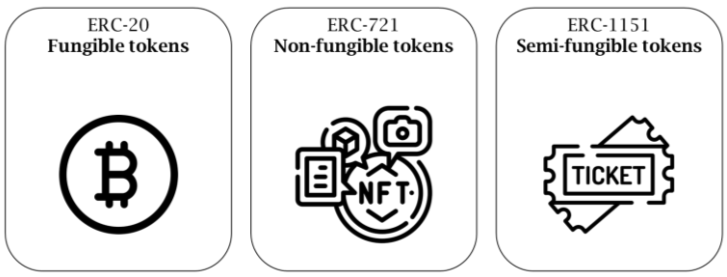
2.2. What is an NFT?

NFTs are a type of cryptocurrency that emerged through smart contracts. Smart contracts are needed for NFTs to work. A smart contract is a computer program that contains code that can be read by a machine. Once a smart contract has been created, it can be executed autonomously and no longer needs to be monitored (Mohanta et al., 2018). A smart contract can be described as a digital contract that is tamper-proof. The code of the smart contract contains the conditions for carrying out the transaction (Ali & Bagui, 2021).

Compared to the classic cryptocurrency, an NFT represents ownership of a unique digital or physical item (Borri, Liu, & Tsyvinski, 2022). For this reason, NFTs can be clearly distinguished from each other. According to Valeonti et al. (2021), an NFT is a cryptographically unique, inseparable, irreplaceable, and verifiable token that represents a specific item, either digitally or physically, on a blockchain. Another reason for the emergence of NFTs was the developer of the blockchain system Ethereum, Vitalik Buterin, who wanted to use the blockchain concept for more than just money (Buterin, 2013).

Besides NFTs, there are cryptocurrencies on the blockchain, which can be understood as digital currencies that can be transferred without a middleman (Ali & Bagui, 2021). While cryptocurrencies, also called fungible tokens, operate in the ERC-20 standard, non-fungible tokens operate in the ERC-721 standard. This is the technological framework and best practices for the creation of tokens (Wang & Nixon, 2021). These standards guarantee developers that NFTs can remain in operation permanently (Ali & Bagui, 2021). The introduction of a new token standard was essential because there are major differences between the two standards. ERC-20 tokens can be divided into small pieces, as well as exchanged between two individuals without any losses or gains. An ERC-20 token can be thought of as a banknote that can be exchanged with any other banknote of the same value (Valeonti et al., 2021). In contrast, ERC-721 tokens are individual and cannot be shared or compounded with other tokens (Wang & Nixon, 2021). Initially, NFTs were created on the Ethereum blockchain, but more and more blockchain systems are using their own NFT standard. The third standard is semi-fungible tokens, which have properties of both fungible and non-fungible tokens (Bamakan, Nezhadsistani, Bodaghi, & Qu, 2022). These include, for example, airline tickets or movie tickets. Figure 1 shows the differences between the tokens.

Figure 1. Overview of different tokens



Source: Based on Bamakan et al. (2022).

One exemplary application of NFTs is the game *Axie Infinity*. In this game, NFTs represent digital collectible creatures. The goal of the game is to collect digital avatars and use them in combat and other activities (Axie Infinity, 2021). Each NFT in this game represents a unique digital asset that is stored and decentralized on the blockchain. A starter set for the game costs about $300. Each time an Axie Infinity NFT is sold on the marketplace, the developer receives a fee, which is the source of revenue (Perry, 2022).

3. RESEARCH APPROACH

This article applies an SLR to capture the current state of the art in the NFT field. The literature review is conducted according to the model of Kitchenham and Charters (2007). An SLR is an appropriate research method for obtaining the most fully available research on a particular research question or topic area (Kitchenham & Charters, 2007). To answer the previously defined *RQ1*, an SLR, therefore, was found to be a meaningful research method. By applying this technique, the goal was to

find and identify the complete available literature on NFTs. The literature search was limited to English literature.

In order to find more relevant literature, we conducted an iterative systematic literature review (Brée & Karger, 2022). In the first iteration, the goal was to obtain an overview of NFT use cases. Based on an initial understanding of the identified results, the second iteration of the literature search was conducted. This second iteration consisted of three different search strings that were applied in the scientific databases. The areas of art and collectibles, video games, and the metaverse emerged as core use cases after the initial literature search. Based on the results of the first iteration, the search strings for the second iteration were adapted to the use cases that were found. Due to the novelty of NFTs, the literature density is low. Table 1 lists the search strings used in each search.

Table 1. Overview of the used search strings for each literature review

Topic	*Search strings*
First iteration: Literature search on NFTs and use cases	
NFTs and use cases	("nft" *or* "nfts" *or* "non-fungible token" *or* "non fungible token") *and* ("use cases" *or* "use case" *or* "application" *or* "use-case") *and* ("blockchain" *or* "distributed ledger")
Second iteration: Literature search on found use cases in the NFT area	
NFTs and art/collectibles	("nft" *or* "nfts" *or* "non-fungible token" *or* "non fungible token") *and* ("blockchain" *or* "distributed ledger") *and* ("art" *or* "picture" *or* "image" *or* "collectibles")
NFTs and video games	("nft" *or* "nfts" *or* "non-fungible token" *or* "non fungible token") *and* ("blockchain" *or* "distributed ledger") *and* ("games" *or* "video games")
NFTs and metaverse	("nft" *or* "nfts" *or* "non-fungible token" *or* "non fungible token") *and* ("blockchain" *or* "distributed ledger") *and* ("metaverse")

The literature search was conducted in the following databases:

- AIS Electronic Library (https://aisel.aisnet.org)
- EBSCO Host (https://search.ebscohost.com)
- Emerald Insight (https://www.emerald.com/insight/)
- Proquest (https://www.proquest.com/)
- Science Direct (https://www.sciencedirect.com/)
- SpringerLink (https://link.springer.com/)
- Web of Science (https://webofscience.com/)
- Wiley Online Library (https://onlinelibrary.wiley.com/)

To the best of our knowledge, these databases contain almost the entire spectrum of the most important conference and journal publications in the field of information systems (IS) and computer science. The following Table 2 gives an overview of the literature search process and shows the search hits in each step.

Table 2. Overview of the elimination criteria and the final number of publications

	Sample after the search in the databases	*Sample after elimination of duplicates and publication without access*	*Sample after reading the title, abstract and keyword*	*Sample after reading the full text*	*Publication identified by a backward search*	*Final sample*
First iteration: Literature search on NFTs and use cases						
NFTs and use cases	187	167	29	8	1	9
Second iteration: Literature search on found use cases in the NFT area						
NFTs and art/collectibles	122	99	34	6	1	7
NFTs and video games	71	55	11	5	1	6
NFTs and metaverse	27	24	9	4	0	4

To get to the final sample, several rounds of eliminations were performed to reduce the number of publications. First, inaccessible publications were eliminated as well as duplicates. Second, publications that did not fit the topic were excluded after reading the title, abstract, and keywords. In the third step, the remaining papers' full texts were investigated. If a paper was relevant to the results, it was added to the final sample. For a paper to be considered relevant, it must map use cases in the NFT domain. In the first iteration, papers representing general use cases were selected. In contrast, the second iteration's focus was on the specific use cases, and only the appropriate papers were selected. In the last step, a backward search was performed to identify further relevant literature. Table 3 contains the complete final sample of the literature search.

Table 3. Complete overview of this paper's final sample

Year	*Author*	*Title*
		NFTs and use cases
2021	Ali and Bagui	Introduction to NFTs: The future of digital collectibles
2019	Besançon, Da Ferreira Silva, and Ghodous	Towards blockchain interoperability: Improving video games data exchange
2021	Fowler and Pirker	Tokenfication — The potential of non-fungible tokens (NFT) for game development
2022	Parham and Breitinger	Non-fungible tokens: Promise or peril?
2022	Park, Kietzmann, Pitt, and Dabirian	The evolution of nonfungible tokens: Complexity and novelty of NFT use-cases
2021	Rehman et al.	NFTs: Applications and challenges
2021	Valeonti et al.	Crypto collectibles, museum funding and OpenGLAM: Challenges, opportunities and the potential of non-fungible tokens (NFTs)
2021	Wang and Nixon	Sok: Tokenization on blockchain
2021	Wang, Li, Wang, and Chen	Non-fungible token (NFT): Overview, evaluation, opportunities and challenges
		NFTs and art/collectibles
2022	Chalmers et al.	Beyond the bubble: Will NFTs and digital proof of ownership empower creative industry entrepreneurs?
2021	Franceschet	The sentiment of crypto art
2022	Hern and Milmo	NFTs: The great rush may be over — But are they in actual decline?
2022	Kharitonova and Rahmatulina	Technological convergence and the future of copyright
2021	Mackenzie and Bērziņa	NFTs: Digital things and their criminal lives
2021	Patrickson	What do blockchain technologies imply for digital creative industries?
2021	Ross, Cretu, and Lemieux	NFTs: Tulip mania or digital renaissance?
		NFTs and video games
2022	Bamakan et al.	Patents and intellectual property assets as non-fungible tokens; Key technologies and challenges
2020	Chen	Blockchain and the feature of game development
2021	Karapapas, Pittaras, and Polyzos	Fully decentralized trading games with evolvable characters using NFTs and IPFS
2022	Kshetri	Scams, frauds, and crimes in the nonfungible token market
2020	Manzoor, Samarin, Mason, and Ylianttila	Scavenger hunt: Utilization of blockchain and IoT for a location-based game
2022	Harviainen, Serada, and Sihvonen	Cryptogames as drivers for blockchain application development
		NFTs and metaverse
2022	Bao and Roubaud	Non-fungible token: A systematic review and research agenda
2022	Lee and Kim	Utaut in metaverse: An "Ifland" case
2022	Park and Kim	A metaverse: Taxonomy, components, applications, and open challenges
2022	Tayal, Rajagopal, and Mahajan	Virtual reality based metaverse of gamification

4. RESULTS

This section presents the results of the literature review. It has to be stated that the number of hits in the literature search is low due to the novelty of NFTs. Currently, the areas of art and collectibles, video games, and the metaverse represent the main areas of NFTs. Furthermore, future use cases are presented that are based on the ideas of individual researchers, as they are still concepts at this stage. At the end of this section, the challenges of NFTs are explained, and the future research agenda is presented.

4.1. Art and collectibles

NFTs are a potential answer to one of the biggest problems in the digital art community, namely how artists can keep their art scarce even though it is easily copied and distributed (Park et al., 2022). The creative industry is among the industries that use NFTs the most. The creative industry includes entrepreneurs and creators such as musicians, artists, designers, and photographers, as well as companies that support the production and distribution of creative goods, such as art galleries, recording studios, publishers, and others (Chalmers et al., 2022).

Through NFTs, artists have been given the opportunity to sell their art digitally. For an artist to create their art as an NFT, an Ethereum wallet, such as Meta Mask, is required. Through websites such as OpenSea.io, images or videos can be uploaded, and the file must be named, then a token is created from it (Kharitonova & Rahmatulina, 2022). Tokenizing intellectual property has revealed a new revenue stream for artists.

In the case of digital art, the purchase of an NFT entitles you to standard usage rights, such as posting the image as a profile picture or using it online (Ross et al., 2021). Ruiz (2021) refers to these rights as "bragging rights", which can be used to show the recording in the blockchain. Due to the increased popularity, many works are fraudulently put up for sale as NFT, even though the required rights are not available. Therefore, gatekeeper galleries are becoming increasingly important to avoid such practices (Patrickson, 2021). A special feature is resale royalties. When an artist's NFT is resold, the artist receives a commission on it. The creator of the NFT can choose how high this commission should be (Mackenzie & Bērziņa, 2021). On March 11, 2021, the digital image "*Everydays: The First 5000 Days*" was sold for $69.3 million, which was the highest NFT sale ever (Patrickson, 2021).

There are also other examples of digital collectible items, such as Crypto Punks. This involves 10,000 different digital art objects that reside on the Ethereum blockchain (Park et al., 2022). The Twitter co-founder and CEO, Jack Dorsey, also tokenized the platform's first tweet, selling it for just under $3 million (Sandler, 2021). Another

notable collectible market is NBA Top Shot. Short videos of NBA moments are sold as NFTs (Mackenzie & Bērziņa, 2021). Over 7.6 million Top Shots moments have already been sold (Wang et al., 2021).

4.2. Video games

In the video game industry, NFTs are taking on greater importance due to the possibility of in-game collectibles and microtransactions (Park et al., 2022). Virtual items play an important role in online games. NFT video games can be divided into classic video games that make use of NFTs and blockchain-based video games. Blockchain-based video games have NFT usage at their core, and an economy is emerging around the game. In 2018, the *Blockchain Gaming Alliance*[3] was founded with the goal of exploring blockchain in gaming (Manzoor et al., 2020). The goal of this alliance is to share best practices and develop common standards. It also aims to better educate the public about blockchain gaming.

In classic video games, NFTs serve as add-ons, such as in Ubisoft's Ghost Recon Breakpoint, where NFTs enable cosmetic changes in the game (Heilbuth, 2022). Through NFTs, players can convert virtual items into real money (Chen, 2020). Often this possibility is used to save time within the game. By selling virtual items, users can even earn money if they can be sold at a profit. This can also be an advantage for developers, as they can receive a part of the revenue as a provision for each resale (Rehman et al., 2021). If a video game developer discontinues support for a game, the digital assets can still be preserved through the blockchain. Thus, the digital assets are not tied to the developer's servers but truly belong to the users (Rehman et al., 2021). This makes it possible to import the assets into another game and continue using them there.

CryptoKitties[4], a game developed by the company Dapper Labs, was one of the first blockchain-based video games to use NFTs and worked on the Ethereum blockchain. This game allows players to collect and breed virtual avatar cats, as well as buy and sell them on the Ethereum network. As of September 2018, over 1 million digital avatar cats have already been grown. Later, in order to expand the platform's functionality with features like animations, the platform moved to a blockchain developed by Dapper Labs itself, called Flow (Ross et al., 2021). Each digital cat is unique and is recorded by an individual text string on the blockchain (Patrickson, 2021). In 2018, one digital asset of this game was sold for $140,000 (Mala, 2018).

4.3. Metaverse

The basic idea of the metaverse is a virtual shared space where all kinds of digital activities can be performed. Examples of activities are playing games, exhibiting art, or exchanging items or virtual goods (Wang et al., 2021). With NFT tokens, a separate economy is created, and a blockchain-based metaverse uses the blockchain as a core technology (Vidal-Tomás, 2022). Users can buy virtual land as NFTs and add different things to this land, such as example, 3D models, music, or videos, or even create their own games (Besançon et al., 2019). For this purpose, the programming language of the platform must be used.

According to Lee and Kim (2022), metaverses will fundamentally change the way people communicate, interact, create values, and generate economies. By 2024, the market volume is expected to grow to $800 billion, representing an annual growth rate of 13% ("Metaverse may be $800 billion market", 2021). Also, Lee and Kim (2022) believe that the metaverse can provide a virtual economy for various business sectors.

An extension of the metaverse is the use of virtual reality technology. In virtual reality, a more immersive experience is created through 360-degree graphics, sounds, videos, and haptic feedback (Tayal et al., 2022). For the user to enjoy a full virtual reality experience, expensive hardware is required. Inexpensive adapters to convert the smartphone into virtual reality glasses are possible but only provide a limited experience (Tayal et al., 2022).

If players were to communicate via peer-to-peer connections, this would have the advantage for developers of no longer needing their own servers since the work can be outsourced to the users' computers. On the other hand, developers would have less control over the game, and it would be easier to modify the content, which is not desired by the developers (Besançon et al., 2019).

One of the best-known NFT-based metaverses is *Decentraland*[5]. The currency used in Decentraland is called MANA. Decentraland is a decentralized metaverse and is managed by the users. Through voting, users can decide how the metaverse evolves. With MANA, transactions can be carried out in Decentraland, and virtual land can be purchased. To become a citizen in Decentraland, LAND must be purchased, which is a 16m-by-16m area. LAND can be freely gated or sold through the marketplace. For one block of LAND the price is about $6000 (Dowling, 2022).

4.4. Future use cases

Due to the novelty of NFTs, many projects have not yet been realized. Many projects are, therefore, only concepts. Bamakan et al. (2022) present a system to tokenize patents. This is intended to create an infrastructure to store patents on the blockchain. Furthermore, a marketplace connected to the blockchain is to be created where patent owners can sell their patents (Bamakan et al., 2022). Mohanta et al. (2018) also present digital rights management as a use case. Smart contracts could be used to transfer the patents as NFTs.

Regner, Schweizer, and Urbach (2019) designed a ticketing system and built a prototype. For tickets to events, there is a secondary market where the seller can call an arbitrary price. There is a risk of purchasing invalid tickets. Regular tickets can also be copied and thus sold multiple times, although only one of them is valid. NFTs can guarantee the uniqueness and authenticity of the tickets.

[3] https://www.blockchaingamealliance.org/our-mission/
[4] https://www.cryptokitties.co
[5] https://dao.decentraland.org/en/

4.5. Challenges of NFTs

Due to the young age of NFTs, there are still some challenges to be solved in this area. When a new NFT is created, this process is called minting. In the meantime, there are platforms like Mintbase or Mintable which support the creation of an NFT. The cost to mint an NFT varies greatly but is over $50 (Wang et al., 2021). Another important aspect is the storage of digital assets. In most cases, the assets are stored outside the blockchain due to the high fees. The NFT data is stored in a cryptographic hash to avoid the high fees. Many NFT projects use special file storage systems, such as IPFS. IPFS is a protocol that exchanges files via peer-to-peer transfer (Karapapas et al., 2021). Here, the hash value of the NFT is chosen to represent the file. At the same time, there is the possibility of encrypting the file against unauthorized access (Bamakan et al., 2022). For the data to be retrieved, a user on that network must have a copy of the file. Here, there is a risk that the file will eventually become unavailable if it is uploaded when the NFT is minted (Wang & Nixon, 2021). If the file is stored on a server of a company, the content of the NFT can also no longer be accessed if this company goes out of business (Fowler & Pirker, 2021). This can violate the NFT system and reduce credibility.

One of the biggest problems is the lack of regulation of NFTs. There is no control unit that monitors and regulates the market. Trading in NFTs is not monitored, and there are no restrictions (Rehman et al., 2021). Therefore, NFTs do not have a regular value but only the value that the market determines for the respective NFT (Fowler & Pirker, 2021).

The energy consumption required to confirm NFT transactions is very high (Golosova & Romanovs, 2018). While Ethereum is trying to reduce this consumption by switching the consensus mechanism, the consumption is still high. Cryptocurrencies, in particular, have been repeatedly criticized for their high energy consumption, which contributes to global warming (Rehman et al., 2021).

One overarching risk that affects Proof of Work based blockchains, and, therefore, many NFT projects, is called a 51% attack (Parham & Breitinger, 2022). If a group of attackers can get together and claim 51% of the computing power, then they can block new transactions (Golosova & Romanovs, 2018). Large networks such as Bitcoin or Ethereum have a low risk of such an attack because of the enormous computing power required and the high level of decentralization of the platforms.

4.6. Future research agenda

In the previous sections, various use cases of NFTs were presented. Despite the research that has already been done in this area, there are still many areas and opportunities for future research. This section identifies future research questions that encompass both NFT in general and the respective use cases. Table 4 provides an overview of future research questions.

Table 4. Future research agenda

Use case	*Future research topics*
NFT	• Which research method is suitable for further studies in the field of NFT? • How can the availability of data represented by NFTs be guaranteed? • How can the safety of NFTs be guaranteed? • Which consensus algorithm is best for NFTs? • How can easy usability of NFTs be achieved?
Art/collectibles	• How can copyright violations be better detected? • How can a copyright violation be handled efficiently? • How can the right to use the artwork be improved? • Do regulations need to be introduced in the NFT art market?
Video games	• Do NFTs add value to video games, or do they reduce their usefulness? • Is the scalability of the blockchain sufficient for a popular NFT video game? • How can NFT interested parties be better educated about the risks?
Metaverse	• Which consensus algorithm is best suited for the metaverse? • How can user data be protected in the metaverse? • How can the metaverse be moderated to protect users from inappropriate content? • How can successful addiction prevention towards the metaverse emerge?
Future use cases	• Who owns the rights of the patent when it is created as an NFT? • How can a marketplace for patents be organized in a decentralized manner? • Can a ticketing system where fees must be paid with cryptocurrencies reach the mass market? • How can there be easier availability for NFTs to implement a ticketing system?

NFT: Due to the novelty of NFTs, there are still many questions that can drive the development of the technology. Since, at the current time, the practice is evolving faster than the scientific literature on NFTs, the question of appropriate research methods for further studies can drive accelerated development of the scientific field. Problems with the availability of data represented by NFTs are a fundamental issue and need to be addressed to enable the widespread application of this technology. The high popularity of NFTs makes this subject area attractive for attackers to commit fraud (Rehman et al., 2021). There are several consensus algorithms in the blockchain space, and Proof of Work and Proof of Stake is among the most well-known. However, each consensus algorithm has advantages and disadvantages. Therefore, a selection must be made very sensitively, as long-term consequences arise. In a survey of nearly 30,000 participants, less than 50% had heard of NFTs (Lau, 2020). To reach a broader mass, the complexity of NFTs needs to be reduced, which is what the last question deals with.

Art and collectibles: Especially in the art sector, the risks and market manipulations in the NFT market are accumulating. Due to the lack of regulation in the market, price agreements can take place (Chalmers et al., 2022). On the other hand,

regulation can hinder growth and potential benefits (Bao & Roubaud, 2022). For this reason, there needs to be a cooperative interplay between the free character of a blockchain and the centralized regulators, allowing further growth to take place. The legal situation of digital art also needs to be further explored. Current rights for NFT buyers should be questioned as to whether they are sufficient for a purchase (Mackenzie & Bērziņa, 2021). Recent criticisms of NFTs include the potential for fraud (Zaucha & Agur, 2022). To reduce scams, centralized authorities can be used. However, this hinders the advantage of decentralized management of a blockchain. Therefore, further research is needed on how to address these issues by not giving up blockchain's decentralized nature.

Video games: In the video game space, it needs to be examined whether NFTs really offer an advantage over traditional video games. For example, to play the blockchain game *Axie Infinity*, a starter set worth about $300 is needed (Perry, 2022). Due to the high price of some NFT games, it must be questioned whether there is a real added value for users or whether this is just a good source of revenue for developers. Since the speed and scalability of a blockchain depend, among others, on the consensus algorithm chosen, it is important to clarify whether scalability is sufficient as the blockchain video game market continues to grow (Harviainen et al., 2022). There are also risks in the video gaming sector, which can result in the loss of assets. The video gaming sector, in particular, needs to be easily accessible, and therefore, the NFT concept needs to be simplified. This also includes that the risks for users need to be clearly explained (Kshetri, 2022).

Metaverse: Metaverses are characterized by a high number of interactions with increasing numbers of users. To enable responsive interaction, a suitable consensus algorithm must be selected in terms of speed. As new consensus algorithms continue to be developed, there may be new potential for metaverses to be explored in more detail. Data are available in more detail in metaverses than in internet history (Park & Kim, 2022). Therefore, user data must be protected in a particularly secure manner. To achieve this, more research needs to be done on how to protect users. Due to the decentralized management in metaverses, organizations may be needed, such as police or government, to protect users from damage (Park & Kim, 2022). This includes inappropriate content and fraud. How implementation can take place should be further explored.

Future use cases: Since the patent system is a concept, no practical tests have been carried out yet. Since NFTs are not yet regulated, it may become problematic to determine who owns the rights to the patent (Bamakan et al., 2022). This problem must be solved before a real system can be implemented. Today's NFT marketplaces, like OpenSea.io, are centralized. A decentralized marketplace without a centralized managing entity should therefore be closely tested and accordingly needs more research. The ticket system is also only a concept so far. A special feature is the payment of the transaction fee in cryptocurrencies (Regner et al., 2019). This is a hurdle, especially for people who have no experience with cryptocurrencies. In order to be used successfully, methods must be developed to include inexperienced people. Besides that, the second issue is how to reach people who have no experience with NFTs. A ticket system that is appealing to inexperienced users must be easily accessible. Regner et al. (2019) also report this problem and have not yet been able to present a solution, so this problem needs to be better researched.

5. DISCUSSION

In this section, the results are discussed, and implications for the theoretical as well as the practical field are given. The main use cases identified are *art and collectibles*, *video games*, and the *metaverse*. Due to the young age of NFTs, little literature was found. Therefore, the selection of use cases is limited to a small literature sample. The largest use of NFTs can be found in the art sector. An investigation of the art area could highlight some problems. Especially the usage rights of the artworks are limited to "bragging rights" (Ruiz, 2021). Here, it must be critically questioned whether such rights justify a purchase. Furthermore, copying and reminting of already existing artworks is a major problem (Patrickson, 2021). This brings into question the exclusivity of NFTs and puts the entire field in a bad light.

The field of video games is particularly well suited for NFTs. Nevertheless, the costs for an NFT video game are much higher than for a classic video game. If there are frequent transfers of assets in a video game, then the game could suffer due to waiting times. Furthermore, gas fees have to be taken into account. These have fluctuated between 20 Gwei and 475 Gwei on the Ethereum blockchain over the past year (Ycharts, 2022). This volatility could discourage users from paying for the service.

In the practical field, it can be seen that many use cases for NFTs already exist. The potential for NFTs is constantly increasing as new use cases emerge that hold potential for new opportunities. Still, many companies are not yet using blockchains and NFTs. Having that said, it can be an interesting use case for many companies. In a survey, it was found that less than 50% of the respondents did not have any experience with NFTs (Yap, 2022). Before a company thinks about implementing a blockchain-based solution or NFTs, however, an analysis must take place to see if it seems reasonable to use NFTs. The use cases and future use cases presented in this paper can give companies the first idea about possible use cases of NFTs. Also, the strengths and weaknesses of the respective use cases are explained, resulting in a comprehensive overview for companies. Nevertheless, if companies are interested in implementation, further research must be done to fully understand the use case and implement it accordingly in a professional manner.

In the theoretical field, many questions are still unresolved. The list of the most discussed use cases provides an overview that can be taken up by researchers. The future research agenda has made it possible to identify problems that have not yet been clarified. This should encourage other researchers to address the problem in order to generate further clarity on NFTs. In particular, the future use cases

also represent interesting opportunities, both for the theoretical and practical areas. Since these are concepts from individual authors, further research is needed to establish them in practice.

In the use cases described, there are already many practical examples today where the technology is being used. Nevertheless, due to the novelty of NFTs, some things have not been covered by science yet, or are still insufficiently researched. Due to the massive upward trend of NFTs, prices have also risen very sharply. Celebrity endorsements raised the popularity of NFTs extremely quickly (Rehman et al., 2021). In the second quarter of 2022, a negative trend of up to 70% could be observed (Wilhelm, 2022). For example, the first tweet from Twitter was first sold for $2.9 million and later only for $14,000 (Hern & Milmo, 2022). Therefore, the development of NFTs should not be made dependent on market trends but on meaningful use cases.

The selection of literature is limited to scientific sources. Therefore, it may be possible that other use cases have already appeared in practice that has not yet been dealt with in the scientific literature. Hence, the restriction on scientific literature can be seen as a limitation. Due to the rapid development of NFTs, practice is more advanced than scientific research. As a result, other use cases might already exist in practice that science has not yet explored. New use cases are only captured by science at a later stage.

6. CONCLUSION

In recent years, NFTs have become increasingly popular in both research and practice. Digital goods can be kept scarce with the help of a blockchain (Franceschet, 2021). New use cases are emerging as a result of rapid development. However, many companies today are not aware of NFTs yet. Companies need to be educated about the potential applications of NFTs. For this reason, a listing of the best-known NFT use cases is provided in this paper. Possible problems and difficulties are addressed in the future research agenda, which gives an outlook on possibilities and exemplary questions for further research.

In the first step, an iterative SLR was conducted to find NFT use cases most represented in scientific literature. In the first iteration, 12 publications were identified that describe the use cases of NFTs. In the second iteration, three literature reviews were conducted for the use cases of art and collectibles, video games, and the metaverse. Through the three literature searches, 24 publications were found. The analysis of the identified articles answered the *RQ1*, '*What use cases of NFTs are described in the scientific literature?*'. After that, different challenges of NFTs were presented. Further research needs to be undertaken to address the problems. As a second contribution, we developed a future research agenda. The future research agenda presented is based on the prior findings and lists open questions that can be used for further research. It aims to provide scholars and researchers with an overview of the current state of the art within the research field of NFTs. It aims to serve as a platform for further research endeavors and is supposed to guide future researchers on how to advance the field of NFTs. Through the future research agenda, the *RQ2*, '*What are possible future research inquiries in the field of NFTs and their use cases?*' was addressed.

In the area of art, NFTs offer opportunities for artists. Through marketplaces, artists can sell digital art as NFT. The owner of an NFT receives only standard user rights. Changes to the art are not permitted (Ross et al., 2021). Resale royalties are a special feature where the artist receives a commission on resale (Mackenzie & Bērziņa, 2021). In video games, NFTs are becoming increasingly popular as in-game collectibles and for microtransactions (Park et al., 2022). Through NFTs, players can convert virtual items into real money (Chen, 2020). Due to the decentralized storage of the data, the NFTs are not tied to the game servers (Rehman et al., 2021). The metaverse is a virtual shared space in which many types of interactions are possible. In metaverses, everything can be represented that can be programmed with the programming language of the respective platform (Besançon et al., 2019). Due to the young age of NFTs, there are still some challenges to be solved in this area. Often, the files of NFTs are stored outside of the blockchain due to high transaction fees. In the event of a server failure, data loss may occur, making the NFT empty of content and worthless (Fowler & Pirker, 2021). One of the biggest problems is the lack of regulation of NFTs. The NFT market is unsupervised and unregulated. Furthermore, the high energy consumption of blockchains using the Proof of Work consensus algorithm is a problem that needs to be addressed.

Limitations of this study can be seen in the sample of literature and the fast development of NFTs. First, given the novelty of the field, not much research about NFTs exists yet. Many use cases of NFTs that might be applied in practice, already, have not been described by research, yet. Furthermore, due to the fact that NFTs are increasingly applied and investigated for different use cases and applications, this article's results can only represent the current state of the art. It is likely that new use cases will appear, and therefore the completeness of the applications described in this article cannot be guaranteed in the long term.

REFERENCES

1. Ali, M., & Bagui, S. (2021). Introduction to NFTs: The future of digital collectibles. *International Journal of Advanced Computer Science and Applications, 12*(10). https://doi.org/10.14569/IJACSA.2021.0121007
2. Arya, J., Kumar, A., Singh, A. P., Mishra, T. K., & Chong, P. H. J. (2021). *Blockchain: Basics, applications, challenges and opportunities.* Retrieved from https://www.researchgate.net/publication/348307266_BLOCKCHAIN_BASICS_APPLICATIONS_CHALLENGES_AND_OPPORTUNITIES?channel=doi&linkId=5ff72e4992851c13fef7b8d6&showFulltext=true
3. Atici, G. (2022). A review on blockchain governance. In G. M. Mantovani, A. Kostyuk, & D. Govorun (Eds.), *Corporate governance: Theory and practice* (pp. 128–133). Virtus Interpress. https://doi.org/10.22495/cgtapp23

4. Axie Infinity. (2021). *Axie Infinity whitepaper*. Retrieved from https://whitepaper.axieinfinity.com/
5. Bamakan, S. M. H., Nezhadsistani, N., Bodaghi, O., & Qu, Q. (2022). Patents and intellectual property assets as non-fungible tokens; Key technologies and challenges. *Scientific Reports, 12*(1), 2178. https://doi.org/10.1038/s41598-022-05920-6
6. Bao, H., & Roubaud, D. (2022). Non-fungible token: A systematic review and research agenda. *Journal of Risk and Financial Management, 15*(5), 215. https://doi.org/10.3390/jrfm15050215
7. Besançon, L., Da Ferreira Silva, C., & Ghodous, P. (2019). Towards blockchain interoperability: Improving video games data exchange. In *Proceedings of the 2019 IEEE International Conference on Blockchain and Cryptocurrency*. https://doi.org/10.1109/BLOC.2019.8751347
8. Borri, N., Liu, Y., & Tsyvinski, A. (2022). *The economics of non-fungible tokens.* https://doi.org/10.2139/ssrn.4052045
9. Brée, T., & Karger, E. (2022). Challenges in enterprise architecture management: Overview and future research [Special issue]. *Journal of Governance and Regulation, 11*(2), 355–367. https://doi.org/10.22495/jgrv11i2siart15
10. Buterin, V. (2013). *A next-generation smart contract & decentralized application platform* (Ethereum White Paper). Retrieved from https://blockchainlab.com/pdf/Ethereum_white_paper-a_next_generation_smart_contract_and_decentralized_application_platform-vitalik-buterin.pdf
11. Chalmers, D., Fisch, C., Matthews, R., Quinn, W., & Recker, J. (2022). Beyond the bubble: Will NFTs and digital proof of ownership empower creative industry entrepreneurs? *Journal of Business Venturing Insights, 17*, e00309. https://doi.org/10.1016/j.jbvi.2022.e00309
12. Chauhan, A., Malviya, O. P., Verma, M., & Mor, T. S. (2018). Blockchain and Scalability. In *Proceedings of the 2018 IEEE International Conference on Software Quality, Reliability and Security Companion* (pp. 122–128). https://doi.org/10.1109/QRS-C.2018.00034
13. Chen, J.-T. (2020). Blockchain and the feature of game development. In J. C. Hung, N. Y. Yen, & J.-W. Chang (Eds.), *Frontier computing* (Vol. 551, pp. 1797–1802). https://doi.org/10.1007/978-981-15-3250-4_239
14. Dowling, M. (2022). Fertile LAND: Pricing non-fungible tokens. *Finance Research Letters, 44*, 102096. https://doi.org/10.1016/j.frl.2021.102096
15. Fowler, A., & Pirker, J. (2021). Tokenfication — The potential of non-fungible tokens (NFT) for game development. In *Extended Abstracts of the 2021 Annual Symposium on Computer-Human Interaction in Play* (pp. 152–157). https://doi.org/10.1145/3450337.3483501
16. Franceschet, M. (2021). The sentiment of crypto art. In *Proceedings of the CHR 2021: Computational Humanities Research Conference* (pp. 310–318). Retrieved from http://ceur-ws.org/Vol-2989/long_paper10.pdf
17. Gatteschi, V., Lamberti, F., Demartini, C., Pranteda, C., & Santamaría, V. (2018). To blockchain or not to blockchain: That is the question. *IT Professional, 20*(2), 62–74. https://doi.org/10.1109/MITP.2018.021921652
18. Golosova, J., & Romanovs, A. (2018). Overview of the blockchain technology cases. In *Proceedings of the 2018 59th International Scientific Conference on Information Technology and Management Science of Riga Technical University (ITMS).* https://doi.org/10.1109/ITMS.2018.8552978
19. Harviainen, J. T., Serada, A., & Sihvonen, T. (2022). Cryptogames as drivers for blockchain application development. In A. Dingli, A. Pfeiffer, A. Serada, M. Bugeja, & S. Bezzina (Eds.), *Disruptive technologies in media, arts and design* (Vol. 382, pp. 55–61). https://doi.org/10.1007/978-3-030-93780-5_5
20. Heilbuth, H. (2022, May 19). NFTs explained, their role in the future of gaming, and why people hate them. *Gamesradar*. Retrieved from https://www.gamesradar.com/nft-explained/
21. Hern, A., & Milmo, D. (2022, May 6). NFTs: The great rush may be over — But are they in actual decline? *The Guardian*. Retrieved from https://www.theguardian.com/technology/2022/may/06/nfts-rush-decline-jack-dorsey-tweet
22. Jagals, M., Karger, E., Ahlemann, F., & Brée, T. (2021). Enhancing inter-organizational data governance via blockchain — Shaping scopes and research avenues. In *Proceedings of the International Conference on Information Systems (ICIS).* Retrieved from https://www.researchgate.net/publication/355206665_Enhancing_Inter-Organizational_Data_Governance_via_Blockchain_-_Shaping_Scopes_and_Research_Avenues
23. Kandaswamy, R., Furlonger, D., & Stevens, A. (2022). Digital disruption profile: Blockchain's radical promise spans business and society. *Gartner*. Retrieved from https://www.gartner.com/en/doc/3855708-digital-disruption-profile-blockchains-radical-promise-spans-business-and-society
24. Karapapas, C., Pittaras, I., & Polyzos, G. C. (2021). Fully decentralized trading games with evolvable characters using NFTs and IPFS. In *Proceedings of the 2021 IFIP Networking Conference (IFIP Networking).* https://doi.org/10.23919/IFIPNetworking52078.2021.9472196
25. Karger, E., Jagals, M., & Ahlemann, F. (2021). Blockchain for AI data — State of the art and open research. In *Proceedings of the International Conference on Information Systems (ICIS).* Retrieved from https://www.researchgate.net/publication/355174945_Blockchain_for_AI_Data_-_State_of_the_Art_and_Open_Research
26. Kharitonova, Y. S., & Rahmatulina, R. S. (2022). Technological convergence and the future of copyright. In E. G. Popkova (Ed.), *Imitation market modeling in digital economy: Game theoretic approaches* (Vol. 368, pp. 267–274). https://doi.org/10.1007/978-3-030-93244-2_30
27. Kitchenham, B., & Charters, S. (2007). *Guidelines for performing systematic literature reviews in software engineering* (Keele University and Durham University Joint Report EBSE-2007-01). Retrieved from https://www.elsevier.com/__data/promis_misc/525444systematicreviewsguide.pdf
28. Kshetri, N. (2022). Scams, frauds, and crimes in the nonfungible token market. *Computer, 55*(4), 60–64. https://doi.org/10.1109/MC.2022.3144763
29. Lau, K. (2020). *Non-fungible token survey: The next trend in cryptocurrencies?* Retrieved from https://assets.ctfassets.net/hfgyig42jimx/6hIoPzp3vXT9CEIt2uTpwo/392c47a8d8f7c4da8b582a6a8f1463bf/Crypto.com_Survey_Report_-_NFT.pdf
30. Lee, U.-K., & Kim, H. (2022). Utaut in metaverse: An "Ifland" case. *Journal of Theoretical and Applied Electronic Commerce Research, 17*(2), 613–635. https://doi.org/10.3390/jtaer17020032
31. Liu, M., Wu, K., & Xu, J. J. (2019). How will blockchain technology impact auditing and accounting: Permissionless versus permissioned blockchain. *Current Issues in Auditing, 13*(2), A19–A29. https://doi.org/10.2308/ciia-52540

32. Mackenzie, S., & Bērziņa, D. (2021). NFTs: Digital things and their criminal lives. *Crime, Media, Culture: An International Journal.* Advance online publication. https://doi.org/10.1177/17416590211039797
33. Mala, E. (2018, May 18). Who spends $140,000 on a CryptoKitty? *The New York Times.* Retrieved from https://www.nytimes.com/2018/05/18/style/cryptokitty-auction.html
34. Mani, A., Verma, S., & Marwaha, S. (2021). A comprehensive study of NFTs. *International Journal for Research in Applied Science & Engineering Technology, 9*(4), 1656–1660. https://doi.org/10.22214/ijraset.2021.34017
35. Manzoor, A., Samarin, M., Mason, D., & Ylianttila, M. (2020). Scavenger hunt: Utilization of blockchain and IoT for a location-based game. *IEEE Access*, *8*, 204863–204879. https://doi.org/10.1109/ACCESS.2020.3037182
36. Metaverse may be $800 billion market, next tech platform. (2021, December 1). *Bloomberg Professional Services.* Retrieved from https://www.bloomberg.com/professional/blog/metaverse-may-be-800-billion-market-next-tech-platform/
37. Mohanta, B. K., Panda, S. S., & Jena, D. (2018). An overview of smart contract and use cases in blockchain technology. In *Proceedings of the 2018 9th International Conference on Computing, Communication and Networking Technologies.* https://doi.org/10.1109/ICCCNT.2018.8494045
38. Nakamoto, S. (2008). *Bitcoin: A peer-to-peer electronic cash system.* Retrieved from https://bitcoin.org/bitcoin.pdf
39. Parham, A., & Breitinger, C. (2022). *Non-fungible tokens: Promise or peril?* https://doi.org/10.48550/arXiv.2202.06354
40. Park, A., Kietzmann, J., Pitt, L., & Dabirian, A. (2022). The evolution of nonfungible tokens: Complexity and novelty of NFT use-cases. *IT Professional, 24*(1), 9–14. https://doi.org/10.1109/MITP.2021.3136055
41. Park, S.-M., & Kim, Y.-G. (2022). A metaverse: Taxonomy, components, applications, and open challenges. *IEEE Access, 10*, 4209–4251. https://doi.org/10.1109/ACCESS.2021.3140175
42. Patrickson, B. (2021). What do blockchain technologies imply for digital creative industries? *Creativity and Innovation Management, 30*(3), 585–595. https://doi.org/10.1111/caim.12456
43. Paul, J., & Criado, A. R. (2020). The art of writing literature review: What do we know and what do we need to know? *International Business Review, 29*(4), 101717. https://doi.org/10.1016/j.ibusrev.2020.101717
44. Perry, B. (2022, February 2). Current cost of an axie or team of axies. *Loaded Gamer.* Retrieved from https://loadedgamer.com/axie-team-cost/
45. Regner, F., Schweizer, A., & Urbach, N. (2019). NFTs in practice — Non-fungible tokens as core component of a blockchain-based event ticketing application. In *Proceedings of the 40th International Conference on Information Systems (ICIS).* Retrieved from https://www.fim-rc.de/Paperbibliothek/Veroeffentlicht/1045/wi-1045.pdf
46. Rehman, W., Zainab, H. e., Imran, J., & Bawany, N. Z. (2021). NFTs: Applications and challenges. In *Proceedings of the 22nd International Arab Conference on Information Technology (ACIT).* https://doi.org/10.1109/ACIT53391.2021.9677260
47. Ross, D., Cretu, E., & Lemieux, V. (2021). NFTs: Tulip mania or digital renaissance? In *Proceedings of the 2021 IEEE International Conference on Big Data (Big Data).* https://doi.org/10.1109/BigData52589.2021.9671707
48. Ruiz, G. (2021, March 8). Buyer beware: NFTs and intellectual property rights. *Medium.* Retrieved from https://georgeruiz.medium.com/buyer-beware-nfts-and-intellectual-property-rights-9f45b3812e28
49. Sandler, R. (2021, March 22). Jack Dorsey's first tweet fetched $2.9 million in NFT sale — And he donated proceeds to charity. *Forbes.* Retrieved from https://www.forbes.com/sites/rachelsandler/2021/03/22/jack-dorseys-first-tweet-fetched-29-million-in-nft-sale-and-he-donated-proceeds-to-charity/
50. Saraf, C., & Sabadra, S. (2018). Blockchain platforms: A compendium. In *Proceedings of the 2018 IEEE International Conference on Innovative Research and Development (ICIRD).* https://doi.org/10.1109/ICIRD.2018.8376323
51. Siddiqui, Z., & Rivera, C. A. (2022). FinTech and FinTech ecosystem: A review of literature. *Risk Governance and Control: Financial Markets and Institutions, 12*(1), 63–73. https://doi.org/10.22495/rgcv12i1p5
52. Statista. (2022). *Gesamtzahl aller Bitcoin-Transaktionen weltweit von Februar 2017 bis August 2022*. Retrieved from https://de.statista.com/statistik/daten/studie/315084/umfrage/gesamtzahl-aller-bitcoin-transaktionen-weltweit/
53. Tasca, P., & Tessone, C. J. (2019). A taxonomy of blockchain technologies: Principles of identification and classification. *Ledger, 4*. https://doi.org/10.5195/ledger.2019.140
54. Tayal, S., Rajagopal, K., & Mahajan, V. (2022). Virtual reality based metaverse of gamification. In *Proceedings of the 6th International Conference on Computing Methodologies and Communication (ICCMC).* https://doi.org/10.1109/ICCMC53470.2022.9753727
55. Valeonti, F., Bikakis, A., Terras, M., Speed, C., Hudson-Smith, A., & Chalkias, K. (2021). Crypto collectibles, museum funding and OpenGLAM: Challenges, opportunities and the potential of non-fungible tokens (NFTs). *Applied Sciences, 11*(21), 9931. https://doi.org/10.3390/app11219931
56. Vidal-Tomás, D. (2022). The new crypto niche: NFTs, play-to-earn, and metaverse tokens. *Finance Research Letters*, *47*, 102742. https://doi.org/10.1016/j.frl.2022.102742
57. Wang, G., & Nixon, M. (2021). Sok: Tokenization on blockchain. In *Proceedings of the 14th IEEE/ACM International Conference on Utility and Cloud Computing Companion* (pp. 1–9). https://doi.org/10.1145/3492323.3495577
58. Wang, Q., Li, R., Wang, Q., & Chen, S. (2021). *Non-fungible token (NFT): Overview, evaluation, opportunities and challenges.* Retrieved from https://arxiv.org/abs/2105.07447
59. Wilhelm, A. (2022, June 8). The NFT slump is real. *TechCrunch.* Retrieved from https://techcrunch.com/2022/06/08/the-nft-slump-is-real/
60. Yap, D. (2022, April 28). CoinGecko NFT survey 2022. *CoinGecko.* Retrieved from https://www.coingecko.com/learn/nft-survey-2022
61. Ycharts. (2022). *Ethereum average gas price.* Retrieved from https://ycharts.com/indicators/ethereum_average_gas_price
62. Zaucha, T., & Agur, C. (2022). Newly minted: Non-fungible tokens and the commodification of fandom. *New Media & Society*. Advance online publication. https://doi.org/10.1177/14614448221080481

DOI: 10.22495/rgcv12i3p1
URN: urn:nbn:de:hbz:465-20230328-105445-9