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# Between Hype, Hope, and Reality: A Lifecycle-Driven Perspective on Non-Fungible Token

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# BETWEEN HYPE, HOPE AND REALITY: A LIFECYCLE-DRIVEN PERSPECTIVE ON NON-FUNGIBLE TOKEN

*Research Paper*

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## Abstract

*Advocates consider NFTs a potentially disruptive blockchain-enabled innovation. In light of surging popularity and low theoretical insights, we study NFTs from a lifecycle-driven perspective. We develop a taxonomy that adheres to a habitual method and draws on a five-step process of analyzing literature and real-world projects. Our taxonomy contributes to descriptive knowledge by structuring NFTs with 20 dimensions and 77 characteristics along the perspectives of origination, distribution, transfer, trade, and redeem. We enable researchers and practitioners to grasp the NFT phenomenon in a structured manner and demonstrate the applicability of our taxonomy through expert interviews and case studies.*

***Keywords:*** *Web3, Blockchain, Non-Fungible Token, NFT, Taxonomy.*

## 1 Introduction

To some, they are just pixelated JPEGs and digital images with no inherent value; to others, they are the next big thing, the top tech innovation of 2021 (Baculard, 2021), a popular FinTech application, and an essential element for the Metaverse (Bao and Roubaud, 2022). Yet one thing is certain: Non-Fungible Tokens (NFTs) are polarizing and have received much attention over the past two years. In particular, public interest in NFTs exploded after the digital artwork "Everydays: the First 5000 Days" was sold for $69 million at Christie's auction house in March 2021 (Kanellopoulos et al., 2021). It ushered in a hype where, in 2021 alone, the overall NFT trading volume topped $23 billion, a staggering increase of more than 20.000% from less than $100 million in 2020 (Ponciano, 2022). Driving the boom were online marketplaces such as *OpenSea*, which facilitate access and trading of NFTs and remove market entry hurdles. They allow users to trade almost anything, from digital artworks to tweets (Howcroft, 2021), music (Fatemi, 2022), signed copies of scientific papers (Sanders, 2021), the source code of the World Wide Web (Kanellopoulos et al., 2021), and physical assets such as luxury cars (Kölbel et al., 2022).

The surge in popularity and frictionless market access has sparked widespread interest in NFTs, evolving from a niche community of crypto experts to relevance across industries. Well-known companies such as *Louis Vuitton* and *Nike*, as well as celebrities like *Tom Brady*, have jumped on the NFT bandwagon to engage in the crypto world (Porterfield, 2021); and researchers believe that NFTs can potentially revolutionize digital property and transform sectors such as gaming, media, and the arts (Pawelzik et al., 2022; Kanellopoulos et al. 2021). Underlying these high expectations are the technological properties of NFTs. They are unique cryptographic tokens on a blockchain that are inherently non-interchangeable and thus represent a unique artifact with individual characteristics (Kanellopoulos et al., 2021). By twinning an NFT to a physical or digital asset, they are distinct from alternative versions, providing unique value and identifiable proof of ownership to the NFT holder (Regner et al., 2019).

However, despite considerable interest and positive sentiment among enthusiasts, NFTs are still at an early stage of development characterized by both great potential and uncertainty. That reflects in volatile

trading volume, reports of fraudulent activities and rug pulls, and relatively scant attention from the academic community (Bao and Roubaud, 2022). While some publications (see Section 2) address general aspects (e.g., application potentials, legal and technical angles) and sector-specific studies (e.g., NFTs in the financial industry), it remains ambiguous how to characterize NFTs, what they have in common, and how they differ. Although there are non-scholarly (e.g., journalistic articles, blog posts) and non-peer-reviewed publications (e.g., Hartwich et al., 2022) that vaguely touch on this topic, an interdisciplinary academic perspective (such as Heines et al.'s (2021) and Kölbel et al.'s (2022) studies on tokenization in general) that abstracts different concepts and clarifies the NFT phenomenon remains elusive. In this context, Regner et al. (2019) argue that a thorough understanding of NFTs from an Information Systems (IS) research perspective is needed, which provides profound descriptive knowledge about NFTs general characteristics and improves prescriptive knowledge about the process of their development. However, to our best knowledge, no peer-reviewed study addresses this notion. Moreover, we are unaware of any scholarly publication that studies NFTs from a multimodal perspective and contributes to conceptual understanding. Therefore, this study aims to answer the following research question (RQ): **How can NFTs be characterized and differentiated based on conceptually and empirically grounded characteristics?**

To answer our RQ, we propose a taxonomy that assists in classifying NFTs across different levels while identifying commonalities and differences. To this end, we iterate the taxonomy development process of Nickerson et al. (2013). We conduct five iterations, sequentially sourcing literature, startups, consulting reports, and companies. Structured along a five-stage token lifecycle, we derive 20 dimensions and 77 associated characteristics. We validate the usefulness of our multi-layered taxonomy by conducting preliminary expert interviews and classifying a sample of NFT projects.

We aim to address two audiences: First, researchers who analyze NFTs and develop theories, and second, practitioners who design or evaluate NFTs and service offerings. Both groups can use our taxonomy to gain a deeper understanding of the NFT phenomenon, identify typical characteristics and core dimensions, and analyze the NFT market. In doing so, our theoretically derived and empirically adapted taxonomy can serve as an overview of the status quo and a basis for further research.

The remainder of this paper is organized as follows. First, we provide background information on NFTs and related work. Second, we outline our research methodology. Third, we present our lifecycle-driven NFT taxonomy. Fourth, we preliminary evaluate our findings by experts and apply the taxonomy to real-world examples. Fifth, we discuss the implications and limitations of our work. Finally, we conclude with an outlook on future research avenues.

## 2 Background & Related Work on Non-fungible Tokens (NFTs)

Adherents of a tech movement known as *Web3* argue for a trustless online world where blockchain-based applications form the backbone of new markets without digital gatekeepers but with empowered users (Kölbel et al., 2022b). Using automated software termed *smart contracts*, interactions should operate without the need for intermediaries, with consensus protocols ensuring proper execution across a peer-to-peer network of nodes (Regner et al. 2019). Cryptographic tokens that are defined in smart contracts and represent arbitrary information and rights (e.g., payment/cryptocurrency, programmable assets, access, or voting rights), are an essential part of blockchain networks. As such, we distinguish between *Fungible Tokens* (FTs) and *Non-Fungible Tokens* (NFTs). FTs are exchangeable and divisible, meaning that any unit representing an asset (e.g., cryptocurrencies such as *Bitcoin*) can be exchanged with the same amount of any other unit of the same asset without profit or loss. NFTs, on the other hand, are neither exchangeable nor divisible, meaning they have individual information and properties that make each token unique. As such, they intend to represent the physical world with its economic properties (i.e., there can be multiple cars of the same type, but not the same car twice) in the digital realm and enable digital scarcity (Pawelzik et al., 2022). Standards such as *Ethereum Request for Comments* 721 (ERC-721) thereby specify that each NFT has a unique ID, token contract address, and creator address, is transferable on the *Ethereum* network, and can optionally contain metadata,

qualifying it to represent utility and ownership of physical and digital assets in a variety of use cases (Guadamuz, 2021; Fai, 2021; Regner et al. 2019).

Initially, leading actors in NFT development were practitioners from crypto communities, who, for example, developed the virtual online game *CryptoKitties* as an NFT application in 2017 (Regner et al. 2019), and subsequently explored other domains and use cases (e.g., digital collectibles, artworks, software licensing, real estate). On the academic horizon, research on NFTs has also been slowly picking up momentum over the past two years following NFTs increasing relevance and popularity on the one hand and the challenges of the novel technology (e.g., cross-chain interoperability, "pull the rug" dilemma, sustainability) on the other. While Regner et al. (2019) reference few peer-reviewed studies, we identified several more recent publications that address the NFT phenomenon. They range from application areas (Ante, 2021; Kugler, 2021; Mazur, 2021; Rehman et al., 2021; Regner et al., 2019), technical properties (Karandikar et al., 2021; Uribe and Waters, 2020), and legal implications (Murray, 2022; Okonkwo, 2022; Bernardino et al., 2021; Aksoy and Üner; 2021; Chirtoaca et al., 2020) to marketing aspects (Colicev, 2022; Chohan and Paschen, 2021), challenges and opportunities (Fowler and Pirker, 2021; Popescu, 2021; Rehman et al., 2021; Valeonti et al., 2021). In addition, scholars explore NFTs in the financial sector, studying market and pricing mechanisms (Dowling, 2022a, 2022b; Horky et al., 2022; Pinto-Gutiérrez et al., 2022), potentials as alternative investments (Borri et al., 2022; Schaar and Kampakis, 2022; Xia et al., 2022), and the impact of NFTs on the price of physical products (Kanellopoulos et al., 2021). Finally, the risk-return characteristics of NFT startups relatively and compared with other alternative assets have also been investigated (Kong and Lin, 2021). In sum, NFTs may disrupt existing business models and creates new ones in multiple domains. However, research lacks an interdisciplinary perspective that characterizes NFTs and abstracts their concepts. We argue that a taxonomy is an effective method for structuring the results of previous research, facilitating the handling of individual cases, and allowing general statements about the interrelationships or differences between certain objects (Doty and Glick, 1994).

# 3 Methodological Research Design

In our study, we combine qualitative and quantitative research. We develop a taxonomy that, as essential prerequisites for understanding a domain (Skopinski et al., 2019), helps to empirically analyze the types, characteristics, and dimensions of NFTs. As such, it serves both researchers and practitioners in explaining similarities and differences between objects and provides order to the complex and rapidly growing field of NFTs (Nickerson et al., 2013). We use examples from real-world projects to classify NFTs and evaluate our taxonomy. Methodologically we build on the iterative taxonomy development process as per Nickerson et al. (2013), which combines practicality with scientific rigor while being used in similar research endeavors in IS research (Kölbel et al., 2022a; Weking et al., 2020). In a nutshell, the process comprises seven steps, which we iterated five times (see Figure 1).

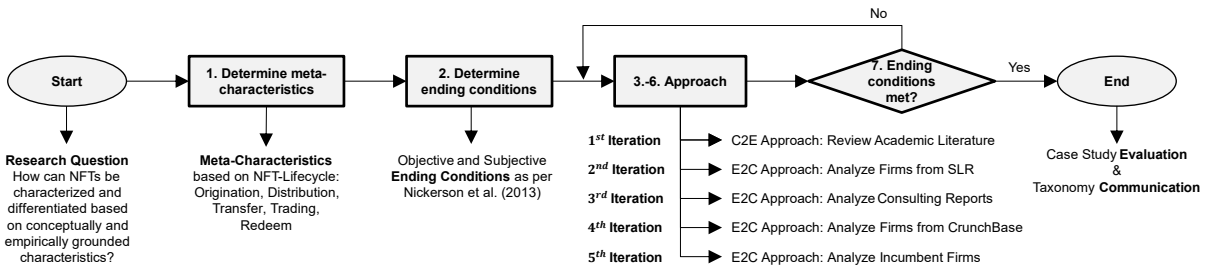



*Figure 1. Research model in accordance with Nickerson et al. (2013).*

**Meta-Characteristics.** As a first step, we defined foundational characteristics to guide all other attributes of the taxonomy (Nickerson et al., 2013). In doing so, we draw on two sources (Karandikar et al., 2021; Stefanoski et al., 2020) that classify NFTs in a lifecycle relative to their value creation, thereby forming five meta-characteristics: Origination, Distribution, Transfer, Trade, and Redeem (see Table 1).

| Meta-Characteristic | Description |
|---|---|
| Origination | Specifies NFT origination and token properties defined during the minting process. |
| Distribution | Specifies NFT distribution and corresponding options for decision-making. |
| Transfer | Specifies NFT transfer processes and parameters between seller and buyer. |
| Trade | Specifies NFT trading on both primary and secondary markets. |
| Redeem | Specifies the owner's redemption, including purpose and domain of an NFT. |

*Table 1. Definition of meta-characteristics.*

**Ending Conditions.** In the second step, we defined subjective and objective ending conditions. In doing so, we followed Nickerson et al.'s (2013) proposal for objective ending conditions (e.g., "at least one object is classified under every characteristic of every dimension," "no new dimensions or characteristics were added in the last iteration," "no dimensions or characteristics were merged or split in the last iteration"). If the taxonomy is concise, robust, comprehensive, extendible, and explanatory, we assumed subjective ending conditions to be met (Nickerson et al., 2013).

**Iteration Phase.** After setting our baseline, we iteratively developed the taxonomy using mixed data (Steps 3-7) and therefore adopted both empirical-conceptual and conceptual-empirical approaches. In the conceptual-empirical, we deductively analyzed authors' knowledge in the literature on NFTs, derived characteristics, and grouped them into dimensions, which we then linked to real-world objects. In the empirical-conceptual approach, we operated vice versa, inductively evaluating real-world objects for shared characteristics and dimensions to expand our taxonomy. After each iteration, we revised the taxonomy and repeated the process until the ending conditions were met.

**Conceptual-to-Empirical (C2E).** The first iteration draws on a literature review (LR) that establishes a knowledge base on NFTs and provides scientific rigor. We followed the methodological suggestions of Webster and Watson (2002) and reviewed publications in journals and conference proceedings published until August 2022. To define our inclusion and exclusion criteria, we followed a similar approach to other scholars in blockchain research (e.g., Jørgensen and Beck, 2022), as we did not limit our search to the *VHB-JOURQUAL3* ranking or peer-reviewed articles. As such, we intend to account for the short history of NFTs, ensure that our study is as comprehensive and up-to-date as possible, and critically assess non-peer-reviewed material. However, we only considered publications that explicitly focus on attributes or design considerations of NFTs along our meta-characteristics. In total, our LR search (see Figure 2) yielded 41 relevant articles that form the basis for the taxonomies' first draft.

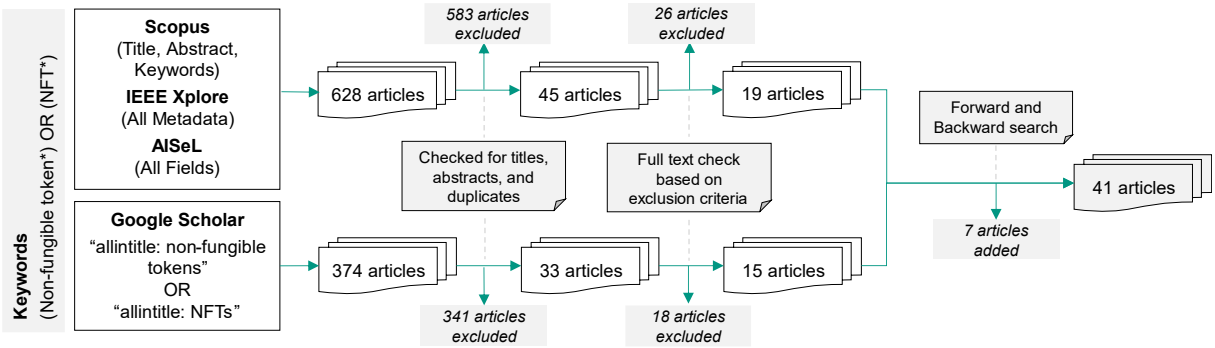



*Figure 2. Literature Review Search Strategy following Webster and Watson (2002).*

**Empirical-to-conceptual (E2C).** We adopted the empirical-to-conceptual approach in iterations 2 to 5 and analyzed NFT firms from four sources. To efficiently build an initial dataset, we first included all ventures emerging from our LR (**Iteration 2**). In doing so, we initially identified 59 firms, but excluded 16 as they no longer exist, have been acquired (e.g., *Niftex*), or did not provide sufficient information (e.g., *NFTfi*). In total, we analyzed 43 remaining firms (see Appendix A). Subsequently, we expanded our sample with consulting reports to capture both strategic and practice-oriented knowledge (**Iteration 3**). Our database drew on two sources: First, the *Vault* (2021) ranking of the top 15 consulting firms worldwide by revenue (as of 2021), and second, the *Ritter*'s (2021) ranking of consulting firms in North America. We compared and merged both lists, resulting in a total of 21 firms, and searched their databases for the query "NFT" OR "Non-Fungible Token". We identified 16 relevant reports (see Appendix B) that add to our taxonomy. Afterwards, we searched publicly available databases for NFT verntures (**Iteration 4**). In doing so, we analyzed a sample of the first 50 firms listed in the *CrunchBase* database (out of 925 hits on May 8, 2022) classified by the keywords "NFT" OR "Non-Fungible Token". As a result, we included 44 new firms in our sample that were not reflected in previous sources (see Appendix C). Finally, we analyzed companies that launched NFT projects in 2021 to gather incumbents' perspectives on the novel and potentially disruptive NFT phenomenon (**Iteration 5**). Since we could not find a database focused on this cohort, our source was a report from *Activate Consulting* (2021). It contains a timeline of 57 companies in different industries that launched NFT projects between January and October 2021 (see Appendix D). We analyzed their cases but could not derive any additional characteristics in this iteration. The sample confirms the existing characteristics and dimensions of our taxonomy. Thus, all objective and subjective ending conditions were met. Based on the aforementioned sources, we are confident that our taxonomy covers the NFT phenomenon comprehensively.

# 4 A Lifecycle-Driven Taxonomy of Non-Fungible Tokens (NFTs)

Figure 3 introduces our taxonomy of NFTs with 20 dimensions and 77 characteristics. It also indicates whether a dimension is exclusive (E) or non-exclusive (N) and in which iteration the attributes were added or revised. For exclusive dimensions, exactly one characteristic is observable at a time; for non-exclusive dimensions, multiple characteristics can be observed simultaneously. Structured along our lifecycle-driven meta-characteristics (see Table 1), we provide details for the dimensions and characteristics below and reference appropriate examples to illustrate and substantiate our findings.

## 4.1 Origination

The first meta-dimension depicts the general purpose and (technical) properties of NFTs that are specified throughout the minting process. We describe corresponding dimensions below.

First, **asset substance** and **value representation** describe the object and content represented by an NFT. It can be a tangible and physical object or an intangible asset of digital nature (Hartwich et al., 2022; Valeonti et al., 2021; Regner et al., 2019). The asset token category includes use cases such as real estate (Fairfield, 2021), digital art (Christie's, 2021), games like *CryptoKitties* (Evans, 2019), intellectual property digitization (Bamakan et al., 2022; Rafli, 2022), and supply chain tracking (EY Global, 2021). Utility tokens are typically used to represent non-investment purposes such as products or services or a token holder's authorization to access them (Wang and Nixon, 2021; Angelo and Salzer, 2020).

Second, **type** describes the design options and adaptability of NFTs. We distinguish five characteristics: static, dynamic, generative, intelligent, and fractional. For static NFTs, which are often defined via the ERC-721 standard, the metadata is fixed as soon as the NFT is minted on a blockchain. As a result, their storage is immutable and traceable, making them particularly suitable for use cases such as play-to-earn games and digital collectibles (Christie's, 2021; Foundation Labs, 2021; Axie Infinity, 2018). Dynamic NFTs, on the other hand, allow metadata modifications by following the ERC-1155 standard. While unique identifiers are maintained, smart contracts facilitate ex-ante adaptation based on previously defined conditions. These conditions can occur either within a blockchain network or outside of it. For example, to account for external conditions, *Chainlink* provides a service that uses data and computation services outside the chain as inputs and triggers for NFT updates (Chainlink, 2022). In addition,

generative NFTs facilitate NFT creation as a whole or in parts by autonomous systems and artificial intelligence (PwC, 2022). This allows, for example, that the characteristics of an NFT artwork are defined autonomously, which would otherwise be determined by the artist. As a result, many unique NFTs can be created in a short time as this type of NFT is popular with buyers due to the unpredictable outcome (Chandra, 2022). Well-known examples include *Bored Apes Yacht Club BAYC* NFTs (2021) and *CryptoPunks* (2017). Intelligent NFTs (iNFTs) are digital assets powered by artificial intelligence (AI) that can embody their own personalities and property rights, bringing NFTs "to life" (Alethea AI, 2022). They are managed on the blockchain and of particular interest for interactions in the Metaverse. For example, *Alethea AI* (2022) created and sold the virtual "Alice" at the *Sotheby's* auction house, which can engage in live conversations with vivid animations (Rasmussen, 2021). Through platforms and protocols, third-party NFT projects (such as BAYC) can also be extended with intelligent functionalities (Altered State Machine, 2021). Finally, we refer to fractional NFTs to describe the concept of splitting NFTs into smaller "shards" (Popescu, 2021). From a technical perspective, an NFT is divided into multiple fungible tokens representing a portion of the original asset, with the creator determining the number of tokens, metadata, and NFT properties (Bamakan et al., 2022; Martinod et al., 2021). This facilitates access, allows different people to own a piece of the same high-priced NFT that would otherwise be difficult to acquire (Bernardino et al., 2021; Pudgy Penguins, 2021), and thus increases market liquidity (Popescu, 2021; Singh and Singh, 2021).

Third, the dimensions of blockchain, network standard, consensus mechanism, and composability describe technical characteristics and fundamental decisions when creating NFTs. As an initial design decision, creators must decide on the **blockchain** to mint an NFT. In theory, any blockchain network that provides protocol definitions and network standards is applicable. However, most commonly, creators (The Sandbox, 2021; Rarible, 2020; Sorare, 2019) reside in Layer 1 blockchains of the *Ethereum* network (Bamakan et al., 2022; Kong and Lin, 2021; Valeonti et al., 2021; Fowler and Priker, 2021). To address anticipated issues of *Ethereum* (scalability, throughput, high transaction costs), projects such as *Audius*, *NBA TopShots*, and *Bitsong* use alternative Layer 1 blockchains such as *Avalanche*, *Flow*, *Cosmos*, and *Solana* or Layer 2 solutions like *Polygon*, *Immutable X*, or *Ronin* (e.g., *Axie Infinity*, *Cent*, *Gods Unchained*). In addition, creators can decide which NFT **network standard** they use. Here, they have several options within a given blockchain ecosystem. For example, while ERC-721 is the commonly used standard for *Ethereum*-based NFTs, alternative standards enable the combination of FTs and NFTs (Ali and Bagui, 2021; Kong and Lin, 2021) within a smart contract (e.g., ERC-1155, ERC-998) or provide interoperability between blockchain ecosystems (e.g., EIP-2981). Depending on blockchain network choice (e.g., *Ethereum*, *Flow*, *Tezos*), the usability of standards also influences the nature of **consensus**. We distinguish five options: Proof-of-Work (PoW), Proof-of-Stake (PoS), Delegated PoS, Proof-of-Authority (PoA), and Proof-of-History (PoH). In addition, the **composability** dimension specifies if an NFT can be bundled to represent hierarchy levels. We differentiate three characteristics: top-down composable NFTs store information about subordinate tokens. For example, an ERC-721 NFT may hold other tokens bundled into a top-down composable. bottom-up composables, on the other hand, store information about parent tokens but do not store information about child tokens (Ross et al., 2022; Uribe and Waters, 2020).

Fourth, **content storage** specifies where the metadata of an NFT is stored. While the storage location is initially determined during the minting process of an NFT, it can be adjusted during its lifecycle depending on the NFT type and preferences (Hartwich et al., 2022). We distinguish three approaches (Wilson et al., 2022; Valeonti et al., 2021; Karapapas et al., 2021). First, creators can store metadata directly on a blockchain (on-chain), which ensures high data availability; however, storage costs can be very high and the data is publicly and transparently accessible. Second, metadata can be stored off-chain on a central server such as *Google Cloud* or *Amazon Web Services*. Here, token purchases and sales are recorded in blockchain ledgers, but the underlying metadata of an NFT can be manipulated without the owner's consent. Third, off-chain storage solutions with decentralized servers such as *InterPlanetary File System* and *Arweave* enable hybrid solutions. Through a peer-to-peer storage network and hashing, they promise both the performance of centralized servers and the immutability of blockchain networks.

| | Dimension | Characteristic | | | | | | | | | | | N/E* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Origination | Asset substance[1] | Digital[1] | | | | | | | | | | Physical[1] | N |
| | Value representation[1] | Asset token[1] | | | | | | | | | | Utility token[1] | N |
| | Type[3] | Static NFT[3] | | Dynamic NFT[3] | | | Generative NFT[3] | | | Intelligent NFT[3] | | Fractional NFT[3] | N |
| | Blockchain[1] | Layer 1[2] | | | | | | | | | | Layer 2[2] | E |
| | Network standard[2] | Ethereum[2] | Flow[2] | Tezos[2] | Zilliqa[2] | NEAR[2] | BSC[2] | TRON[2] | Algorand[2] | NEO[2] | Other Standard[2] | No Standard[3] | E |
| | Consensus mechanism[1] | Proof-of-Work[1] | | Proof-of-Stake[1] | | | Delegated PoS[1] | | | Proof-of-Authority[2] | | Proof-of-History[2] | N |
| | Composability[2] | Bottom-up composable[2] | | | | | Top-down composable[2] | | | | | Not composable[2] | N |
| | Content storage[1] | On-chain storage[1] | | | | | Decentralized storage solutions[4] | | | | | Centralized cloud[4] | N |
| Distribution | Key channel[1] | Open marketplace[1] | | | | | Collection-based marketplace[1] | | | | | Curated marketplace[1] | N |
| | Exclusiveness[2] | One-of-a-kind[2] | | | | | Limited edition[2] | | | | | Open edition[2] | E |
| | Price formation[1] | Fixed price[1] | | | | | Timed auction[1] | | | | | Open auction[2] | E |
| Transfer | Transfer methods[4] | Sell[4] | | | | Lease[4] | | | Gift[4] | | | Airdrop[4] | N |
| | Interoperability[4] | Single-chain NFTs[4] | | | | | | | Multi-chain NFTs[4] | | | | N |
| | Wallet[1] | Custodial wallet[1] | | | | | Non-custodial wallet[2] | | | | | Semi-custodial wallet[4] | N |
| | Copyright[1] | Creator retains copyright[2] | | | | | Creator transfers copyright[2] | | | | | Licenses[2] | N |
| Trading | Payment method[1] | Cryptocurrency[1] | | | | | | | FIAT[1] | | | | N |
| | Fee[2] | Gas fees[2] | | | | | Royalty fees[2] | | | | | Service fees[2] | N |
| | Fee composition[2] | Fixed[2] | | | | | | | Variable[2] | | | | N |
| Redeem | Purpose[3] | Investment[3] | | Display[3] | | | Access[3] | | Engagement[4] | | Burn[4] | Not Specified[4] | N |
| | Project category[1] | Art[1] | Collectible[1] | Sport[1] | Utility[1] | Games[1] | Music[2] | Fashion[2] | Avatars[2] | Usability[4] | Other[4] | | N |

*E = Exclusive dimension (one characteristic observable); N = Non-exclusive dimension (More than one characteristic observable)
Dimensions and characteristics added or revised in the following iteration: [1] first, [2] second, [3] third, [4] fourth iteration

*Figure 3. Lifecycle-Driven Taxonomy of Non-Fungible Tokens (NFTs).*

## 4.2 Distribution

The second meta-dimension depicts the distribution of NFTs. Our taxonomy characterizes key channels, the level of exclusiveness and price formation of an NFT.

The **key channel** dimension addresses NFT sales and is not limited to a specific characteristic. We distinguish three types where NFTs are either specifically distributed or represent an additional feature of an existing brand or auction house (Bodó et al., 2022). First, open marketplaces allow the minting and trading of both NFTs created directly on the platform and otherwise designed NFTs. A prominent example of this category is *OpenSea*, which is available to anyone. Second, there are collection-based marketplaces such as *CryptoPunks* (2017), *NBA TopShots* (2019), and *Christie's* (2021), where NFT collectibles are tied to the creators' infrastructure and cannot be traded on other venues. These marketplaces "create, curate, mint, and promote specific, unique NFT based digital collectibles" (Bodó et al., 2022). For example, by setting access conditions and formulating community norms for the behavior of artists, rights holders, users, buyers, and sellers, they assert strict control. Likewise, the third category of curated marketplaces also exhibits a high degree of control over the artists who create, design, and trade NFTs through their service. However, they do not claim exclusive privileges to create and sell NFTs. Instead, they determine who can trade on their platform via ex-ante review mechanisms for both types and content. Examples include *SuperRare* (2018) and *Nifty Gateway* (2018).

The **exclusiveness** dimension indicates whether an NFT is released as a single piece or in a limited or open edition. For unique pieces, the number of NFTs of the same type is fixed at one, which means that only one collector can own the piece. Being digitally scarce, creations with this characteristic (e.g., digital artwork; Christie's, 2021) can fetch high selling prices. When an NFT is produced in a limited edition, ownership can be distributed among multiple collectors (Hartwich et al., 2022; MakersPlace, 2018). The number of units available is determined during the minting process. In contrast, an open-

edition NFT is designed so that new NFTs of the same type can be minted dynamically depending on their demand, generally qualifying these NFTs as less rare or prestigious (Nifty Gateway, 2018).

The dimension **price formation** separates three mechanisms, where NFT sellers may choose their preferred method (Ross et al., 2022; Mukhopadhyay and Ghosh, 2021). First, the fixed pricing option allows to set a price for a certain period and allows for negotiation. However, the seller is not obligated to settle at a lower price. Second, marketplaces such as *OpenSea* (2022) allow for various timed auction procedures. Here, sellers typically have a choice between an English auction, where the highest bidder receives the NFT after a certain amount of time has elapsed, and Dutch auction procedures, where the price for an NFT decrease (up to a certain limit) until a buyer's willingness to pay is reached. Third, platforms such as *Rarible* (2022) enable open auctions, where an NFT can be indexed as "open for bidding" so that bids can be submitted at any time and accepted or rejected by the owner.

## 4.3 Transfer

The third meta-characteristic depicts the process of introducing an NFT to public markets. We distinguish four characteristics, namely transfer method, interoperability, wallet, and copyright.

First, the **transfer method** specifies how an NFT is disseminated. We discern a permanent transfer (i.e., sell, gift, airdrop) and a temporary transfer (i.e., lease). In the first case, an NFT is transferred from one owner to another. For example, NFTs can be sold directly (Schaar and Kampakis, 2022) or on a pre-approved sale (Hartwich et al., 2022), gifted to registered collectors (OneOf, 2021), or airdropped for free to (whitelisted) community members as a marketing strategy (Chandra, 2022). In the second case, an NFT is leased for a specified period, either restricted or unrestricted. For example, an NFT cannot be sold but only leased if it serves as an authorization key for linked data that is shared (Musan et al., 2020).

Second, **interoperability** concerns whether NFTs are connectable, exchangeable, and tradable only within a blockchain network (i.e., single-chain) or across multiple networks (i.e., multi-chain). For example, in a web3-enabled Metaverse, it is critical to port data NFTs as digital avatars from one virtual world to another (Elmasry et al., 2022). In single-chain networks, common standards enable interoperability within an ecosystem but are primarily limited to that environment (Martinod et al., 2021; Mofokeng and Fatima, 2018). While approaches such as bridges enable *Ethereum*-minted NFTs to be accessible on other blockchain networks (e.g., *Solana*), these solutions might require reliance on trusted third parties and pose security trade-offs (Pillai et al., 2022). Multi-chain networks, including *Cosmos* and *Polkadot*, address these challenges by developing open networks of interoperable blockchains that enable cross-chain communication, where NFT projects can leverage a shared infrastructure (e.g., for consensus), have interacting smart contracts, and share value directly.

Third, **wallets** specify the repository of NFTs, where token custody can be managed by the holder itself or a service (i.e., custodian) that holds an NFT's private key governing its access and ownership (OpenSea, 2022; Valeonti et al., 2021; Rarible, 2020). If holders prefer not to be responsible for the custody of their keys, they can use custodial wallets where platform services provide key custody (Artblocks, 2022). This allows password recovery and account retrieval mechanisms. However, holders must rely on and become dependent on the custodian's security mechanisms. If users prefer to determine the storage of their private keys themselves, they can use non-custodial wallets (OpenSea, 2022). Here, secure storage resides entirely to NFT holders, who must remember their private keys and a backup seed phrase, which they can store in software or hardware wallets. If holders lose this information and thus access to their wallet, their NFT is no longer accessible. In addition, non-custodial wallets are blockchain-specific (e.g., *Metamask* for *Ethereum*; *Phantom* for *Solana*). If a user wants to use both wallet types, he can resort to semi-custodial wallets, where custody is managed by both the NFT holder and a third party (Mojito, 2021).

Fourth, **copyright** characterizes the ownership and exploitation rights of NFTs. A principal owner (e.g., minting creator) may transfer ownership to a subsequent owner (e.g., NFT consumer) or only grant rights to a particular NFT. If creators retain rights to an original, they may reproduce other NFTs based on the same original (Chohan and Paschen, 2021). Examples without a copyright transaction include well-known NFTs such as *CryptoKitties* and *CryptoPunks* (Evans, 2019). Some platforms (e.g.,

Mintable, 2018) offer creators the ability to include copyrights in the smart contract of a sale and transfer intellectual property to buyers (Guadamuz, 2021). Furthermore, NFT rights can also be licensed. Typically, creators grant buyers a license to use, exploit, and display their NFT for a limited period (Guadamuz, 2021) and may also transfer marketing rights (Lee, 2022). An example includes *BAYC*, where buyers receive a license to use their NFT personally and commercially (Guadamuz, 2021).

## 4.4 Trade

The fourth meta-characteristic addresses the trading of NFTs in primary and secondary markets. We distinguish three characteristics, namely payment method, fee, and fee composition.

First, the **payment method** characterizes the currency used to purchase an NFT. A prevalent option are cryptocurrencies (Dowling, 2022a; Chohan and Paschen, 2021), which are either subject to price fluctuations (e.g., *Ether* in the *Ethereum* ecosystem; Fairfield, 2021; Valeonti et al., 2021) or pegged to a FIAT currency (e.g., stablecoins such as DAI; Ante, 2021; Regner et al., 2019). In addition, platforms such as *Nifty Gateway* (2018) also enable payments with FIAT money, which are processed via credit or debit card, and services such as *PayPal* (Ross et al., 2022).

Second, **fees** capture NFT-related expenses incurred as part of a transaction, for providing a service, or as a license fee. By transaction fees, we group expenses that arise using a blockchain infrastructure (e.g., consensus, transaction recording; Reijsbergen et al., 2021). They depend on the network used and can be higher than the price of the transacted asset in some cases. For example, *BAYC* buyers had to pay gas fees that were more than five times the NFTs purchase price (Nover, 2022). In addition, costs depend on whether the transaction is an initial sale or a sale of an NFT on the secondary market (OpenSea, 2022; Mintable, 2018). Secondary market transactions may also involve royalties, which are included as an automatic interest in a smart contract that allows creators to participate by reselling their NFTs (Hartwich et al., 2022; Popescu, 2021; Chohan and Paschen, 2021). A third characteristic is service fees, which include marketplace- or platform-related costs such as registration and account fees. For example, first-time buyers on *OpenSea* (2022) must pay a one-time gas fee that flows to the marketplace operator. However, not every marketplace charges service fees (Bybit, 2022).

Third, the **fee composition** specifies whether fees are fixed or variable. While transaction fees are variable as they depend on factors such as network utilization and cannot be adjusted by creators, the magnitude of royalty fees is usually at their discretion (Guadamuz, 2021). Creators can set royalties as a fixed amount or as a percentage of the sales price. Variable royalties oriented towards resale value are prevalent and range from 0-10% (OpenSea, 2022; Rarible, 2020; Mintable 2018). Service fees, on the other hand, often occur as a fixed amount. For example, *Nifty Gateway* (2018) charges a one-time registration fee on their service of 15%.

## 4.5 Redeem

The fifth and final meta-characteristic concerns the applicability of NFTs. We distinguish two characteristics, namely purpose and project category.

First, **purpose** indicates the intended utilization of an NFT. For example, they may serve as a speculative asset where buyers want to increase the value of their investment. This category is closely related to DeFi ecosystems, where owners can use various DeFi mechanisms (e.g., stake, lend, collateralize) to generate attractive profits (Hartwich et al., 2022). NFTs may also serve as a display mechanism in communities to engage with brands and other users. We distinguish between social engagement NFTs (e.g., badges, emblems, GIFs, and emojis), identity NFTs (e.g., cross-platform avatars or interactive characters), and profile picture NFTs (e.g., on social networks). For example, the *BAYC* NFTs appear on various social media platforms, being considered a digital symbol of social status (Chalmers et al., 2022). We further identify access NFTs that provide permanent or temporary benefits to their holders. These include access to communities, events, music, or exclusive content in both digital and physical realms only NFT holders can access (Hartwich et al., 2022). As such, they grant their holders trademark or commercial rights, licenses, copyrights or voting rights that automatically expire when an NFT is

resold (Ante, 2021). They can also allow participation in exclusive programs and provide credentials to unlock services and rewards. These range from redeemable rewards to discounts on merchandise and new product offerings (Baculard, 2021; Autograph, 2021). Community-organized gatherings are thereby aimed at increasing the perceived value of an NFT. In addition, NFT-based tickets exist where the token contains credentials for a specific event (Regner et al., 2019). After the event, an NFT may serve as proof of attendance and a digital certificate of participation (Zhao and Si, 2021). Furthermore, we consider engagement NFTs to interact in interactive environments such as the Metaverse or virtual games (Hartwich et al., 2022; Lee, 2021). Here, NFTs can represent virtual clothing or digital accessories that their holders can use to dress up their avatar NFTs (Brooks, 2022). We also see immersion between virtual and digital worlds. In games, NFTs can represent characters, skills, and items that subsequently serve as assets to generate income by selling them to other players or collectors or holding them as passive income. Also, NFTs can represent fantasy sports trading cards (PwC, 2022; Lee, 2021, NBA TopShots, 2019). Lastly, the burn characteristic describes a method to reduce the supply of a circulating quantity of NFTs, thereby increasing scarcity and stimulating prices (McDowell, 2022). Given that NFTs minted on a blockchain are immutable and cannot be erased, each token to be burned is thereby sent to an inaccessible address (McDowell, 2022). The transaction is irreversible because the token still exists on the blockchain but is no longer accessible.

Second, the **project category** specifies the use case that an NFT aims to represent. Extant literature distinguishes seven main segments: arts, collectibles, sports, digital fashion, utility, and games (Hartwich et al., 2022; Osivand, 2022; Mukhopadhyay and Ghosh, 2021; Ante, 2021; Musan et al., 2020). Use cases that prior literature did not consider include NFTs for music (Rumburg et al., 2020; Bitsong, 2017), and avatars (Decentraland, 2017). We further identify NFTs to reduce the complexity of blockchain addresses while enhancing usability (Hartwich et al., 2022; Unstoppable Domains, 2018).

# 5 Taxonomy Application and Evaluation

We evaluated the applicability of our taxonomy ex-post by following a threefold approach, drawing on the methodological guidance of Szopinski et al. (2019). **First**, we conducted three preliminary expert interviews with academics and practitioners, which is a widely used tool for taxonomy evaluation in the IS domain (Szopinski et al., 2019). Hereby, we aim to validate the taxonomy's comprehensibility, completeness, and perceived usefulness. When selecting the experts, we focused on the proven NFT expertise and experience as the decisive criterion. We conducted semi-structured interviews using evaluation-typical questions (e.g., “Is the taxonomy adequate and complete? Are all relevant objects included in the taxonomy? Would you suggest modifying the taxonomy? Which dimensions and characteristics should be deleted? Which dimensions or characteristics should be added?”; Szopinski et al., 2019). The interviews lasted an average of 51 minutes and were transcribed and analyzed in an iterative process (Corbin and Strauss, 2008) using *MAXQDA2020* software. **Second**, three individual raters classified 25 randomly selected empirical objects from our corpus (see Appendix A, C) using our taxonomy. The characteristics and dimensions from the preceding sections served as a codebook for the classification. We then calculated the Fleiss kappa (Fleiss, 1971) as a measure of rater agreement and comparability of results, which is also used in other IS publications to evaluate taxonomies (Kölbel et al., 2022a; Weking et al., 2020). The analysis yielded a kappa value of 69%, which corresponds to “substantial agreement” (Landis and Koch, 1977) and thus indicates that our taxonomy is suitable for a coherent classification and concise description of NFTs. **Third**, to substantiate the results and demonstrate the applicability of the taxonomy, we classified three real-world NFT projects using our taxonomy (see Figure 3). Through this illustrative scenario analysis, we aim to evaluate the practical applicability and usefulness for classifying, differentiating, and comparing NFT projects (Szopinski et al., 2019). The selection of cases followed three rationales: (1) Cases represent different approaches, as they portray NFT projects from different domains. *Beeple's* “Everydays: the First 5000 Days” (Christie’s, 2021) is arguably one of the most famous and lucrative digital artworks (Hartwich et al., 2022), and “The Merge” (Nifty Gateway, 2021) also belongs to the domain of NFT art collectibles. In addition, we consider these two works highly relevant, as they are the most expensive NFT ever sold

($69.3 million and $91.8 million; Hale, 2022). "The Top Gun: Maverick Collection" (OpenSea, 2022), on the other hand, represents an NFT project from the entertainment and media industry, where most NFT projects were initialized in 2021 (see Appendix E). (2) Cases represent different types of NFTs. While "Everydays: the First 5000 Days" and "The Top Gun: Maverick Collection" are static NFTs following the ERC-721 token standard, "The Merge" is a dynamic NFT according to the ERC-1155 standard. (3) All three cases provide sufficient information that allows us to analyze them in detail and classify them according to the attributes of our taxonomy. Figure 3 illustrates each case and describes whether and how they fit into our taxonomy.

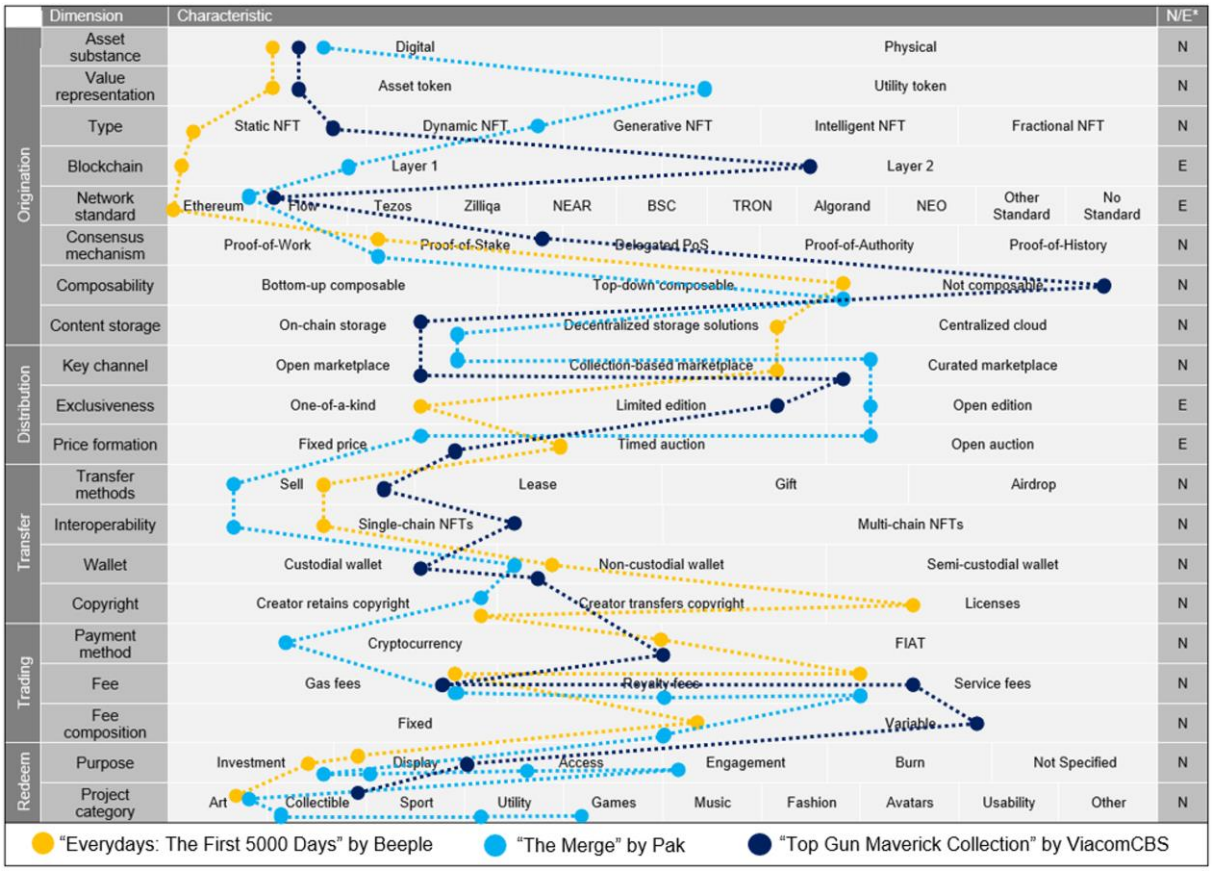



*Figure 4. Taxonomy Application and Evaluation with three real-world NFT projects.*

# 6 Discussion and Conclusion

Our study contributes to descriptive knowledge about the NFT phenomenon by proposing a theoretically grounded and empirically validated taxonomy that focuses on characterizing NFTs along their lifecycle and synchronizes findings from academia and practice. We argue that our broad perspective complements non-peer-reviewed NFT classifications, providing more general applicability that accurately captures the rapidly growing NFT industry. Although previous articles help to initiate a discourse on NFTs, they abstract their mechanisms. Our scientifically grounded perspective, which consists of a five-step research approach incorporating both qualitative and quantitative methods, not only allows us to describe NFTs more comprehensively than previous work (e.g., Hartwich et al., 2022), but also explains previously undocumented phenomena. For example, while extant literature separates core NFT use cases into arts, collectibles, sports, digital fashion, utility, games, and domains, we identify further applications that have not been considered before (e.g., music NFTs, avatar NFTs). Similarly, we identify static, dynamic, generative, intelligent, and fractional NFT types, while alternative classifications only report two characteristics (i.e., static and dynamic NFTs; Hartwich et al., 2022). We

also describe uncharacterized characteristics (e.g., distribution channel, exclusiveness, price formation, wallet, copyright) and specify the technical origins of NFTs (e.g., composability, blockchain, network). Furthermore, we classify NFTs across the domain-independent category of "purpose" and distinguish NFTs for investment, display, access, engagement, and burn mechanisms.

Like any research project, our study is beset with **limitations**. First, given the fast-growing nature of the NFT sector, we do not expect our sample of NFT projects and start-ups to be exhaustive. We aimed to address this by referring to different literature sources, reports, and the *CrunchBase* database. Second, emerging NFT types may be underrepresented in the current sample. For example – given the growing interest in the Metaverse – we assume that iNFTs with AI-supported applications will be more prevalent in the future. Therefore, we have developed our taxonomy to be revisable and expandable to include new perspectives, characteristics, and dimensions (Nickerson et al., 2013). Third, our taxonomy relies on an evaluation process that is notoriously difficult but particularly challenging at the beginning of a new research field (Szopinski et al., 2019). Accordingly, we see our three-stage endeavor as a first step towards evaluation, where follow-up interviews with further experts, and an evaluation with more NFT projects might further confirm or iteratively revise our findings.

Despite these limitations, our study entails **implications** for academia and practitioners that contribute to the scholarly understanding of NFTs. In each of the five lifecycle perspectives, we identify attributes that reflect NFTs' multiplicity and offer a starting point for in-depth understanding. These can serve as a reference for future research. Bapna et al. (2004, p. 23) also note that "a robust taxonomy can be used for ex-post theory building". We argue that our taxonomy enhances the understanding of the NFT domain and thus embodies the most basic form of a theory ("taxonomic theory"; Gregor, 2006), which provides a necessary foundation for more advanced theories (Szopinski et al., 2019; Gregor, 2006). In these efforts, varying levels of abstraction inherent in the dimensions of our taxonomy can have repercussions in downstream theorizing activities, as certain dimensions are more empirical and subject to change (e.g., network standards), while others operate at a higher level of conceptual abstraction (e.g., composability, type). Considering managerial implications, our taxonomy supports practitioners with a status-quo analysis of NFTs, providing a granular overview of design and comparability. For example, NFT developers obtain abstracted knowledge about characteristics and interaction points with potential customers and learn about different NFT applications and purposes. Building on this knowledge, they can design new NFTs, evaluate business ideas, analyze individual offerings of existing projects, and compare competing and non-competing products within and across functional areas. Similarly, NFT clients can use our taxonomy as a tool to compare diverse market offerings to guide informed purchasing decisions. In addition, our taxonomy can support regulators in their standardization efforts.

Our results also motivate **future research**. Amidst dynamic NFT evolutions and rapid technological developments, our taxonomy may serve as a temporary snapshot that can be reviewed iteratively for completeness. Besides, our taxonomy provides a foundation for developing archetypes that may help to derive successful or sustainable NFT design principles. Furthermore, ecosystem aspects (e.g., platforms business models) and NFT-related value co-creation may be analyzed. Given the full transparency of blockchain-based systems (Sedlmeier et al., 2022), we also consider the applicability of NFTs in corporate contexts to be an exciting research topic. Focusing on a specific domain, use case or sub-aspect of NFTs might also add to our taxonomy's level of detail. In this context, it would be interesting to study, for example, how NFTs work within the Metaverse or how NFT-based identities can be compared with dedicated identity solutions such as Self-Sovereign Identity (Sedlmeir et al., 2021).

# Appendix

Art Blocks; Async Art; Atomic Hub; Audius; Axie Infinity; Bitsong; Blockparty; Catalog; Cent; Cryptovoxels; Dapper Labs; Decentraland; Digitalax; Emanate; eMusic; Epix; Foundation Labs; Gods Unchained; InfiNFT; Kalamint; KnownOrigin; MakersPlace; Mintable; Mintbase; MintyArt; NFT Showroom; Nifty Gateway; OpenSea; Opus; Pancakeswap; Paras; PolyientX; Portion; Rarible; SEEN HAUS; Somnium Space; Sorare; Sound; SuperRare; Virtua; The Sandbox; VIV3; Zora

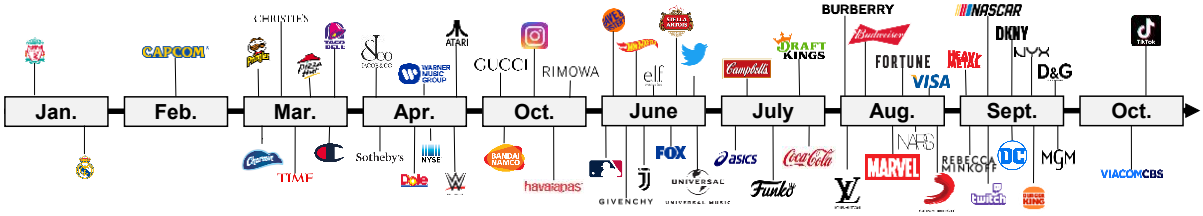
*Appendix A. Analyzed Firms from Literature.*

| Company Name | Search Results | Relevant Reports | Firms mentioned |
|---|---|---|---|
| Bain & Company | 109 | • Nine Tech Innovation Trends Leading the Executive Agenda in 2021<br>• Digital Assets and Blockchain Consulting | NBA Top Shot, Vacheron Constantin |
| Boston Consulting | 39 | • Seven Trends at the Frontier of Blockchain Banking<br>• The Corporate Hitchhiker's Guide to the Metaverse | Rarible, OpenSea, Nonfungible.com |
| EY Parthenon | 13 | • How non-fungible tokens can create value for enterprises<br>• Birra Peroni is the first industrial organization to mint unique non-fungible tokens using EY OpsChain<br>• How taxes on cryptocurrencies and digital assets will soon take shape<br>• How the Metaverse and Web3 are creating real tax issues | EY OpsChain Traceability |
| Deloitte Consulting | 6 | • NFTs and the law - Five non-fungible truths for GCs<br>• Sports NFTs digital athlete media<br>• NFTs and the iteration of football fandom | Gucci, NBA Top Shots, eBay |
| Strategy& PwC | 6 | • Non-Fungible Tokens (NFTs) - Legal, tax and accounting considerations you need to know<br>• NFTs: The future of digital assets in sports | Larva Labs, Nifty, SuperRare, Gateway, Makersplace, Async Art, NBA Top Shot, OpenSea |
| Gartner Inc. | 66 | • Fashion Embraces NFTs<br>• NFTs get AI Brains; What's next for iNFTs?<br>• Think you own your NFT? Think Again | Gucci, RTFKT, Jacob Alethea.ai, Altered State Machine |

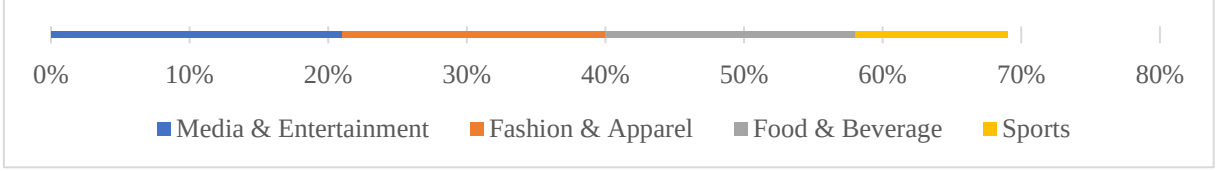
*Appendix B. Analyzed Consultancy Reports.*

Afterparty; Autograph; Avocado Guild; Baller Mixed Relity; BAYZ; Boba Network; Boson Protocol; Burnt; Crypto Raiders; Crypto.com; DEIP; Dfns; Dogami; Double jump.tokyo; FanCraze; Fungyproof; Genopets; Horizon Games; IndiGG; Itheum; Lysto; Magic Eden; Meta Tenure; MetaLend; MetaStreet; Metaverse Group; Mojito; Nifty Island; Novel; OneOf; Palm NFT Studio; Pluto Digital; POAP; Project Galaxy; Proof of Learn; Recur; Royal; Space Runners; Spatial; Unstoppable Domains; Venly; White Sands; Wilder World; Zaiko

*Appendix C. Analyzed Firms from Crunchbase Data.*




*Appendix D. Analyzed Incumbents that launched NFT projects in 2021.*




*Appendix E. Incumbents NFT launches in 2021 by industry with a market share of at least 10%.*

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