Working Paper on a Digital Ecosystem

NON-FUNGIBLE TOKENS

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Introduction

The applications and usage of Non-Fungible Tokens (NFTs) have captured the imagination of the digital asset communities. Not only have NFT gaming applications such as CryptoKitties been one of the most active applications on the Ethereum blockchain, but large monetary values have been involved in both primary and secondary market transfers as well, whether it be for NFTs representing digital art or collectibles. Platforms have already standardized the process of NFT creation and provided artists from around the world a channel to monetize their digital art.

While these applications have been predominant in driving the adoption and standard creation processes for NFTs, we see potential further applications in financial markets, industries, and society. Many projects use NFTs to track ecologic capital, represent verifiable claims of the origin of consumer goods, or represent intellectual property.

This paper aims to describe NFTs, assess their risks and limitations, explore the existing regulation in the European Union and share examples of tokens and existing markets. The paper reports the status quo as of October 2021.

Non-Fungible Tokens – an overview

Definition

So-called *Non-Fungible Tokens* (NFT) represent ownership of the rights over a specific underlying. That underlying could be a picture, a video, an item in a game or the physical world, or a financial contract. The term *Token* describes a smart contract living on a blockchain that represents an ownership registry. The term *Non-Fungible* means that items are in some form *unique* and not interchangeable. Two 5 EUR bank notes for example are interchangeable whereas two different videos are not.

As with all tokens, an NFT implements basic functionality with respect to the ownership registry:

- *claim of ownership*: a holder (person, entity, or machine) can prove the ownership of the underlying which is identified by the token
- *transfer of ownership*: the ownership of the rights associated with an underlying can be transferred to another holder (person, entity or machine)

So in short, when examining NFTs and their potential, three aspects should be considered: *ownership*, *transfer* and *uniqueness*.
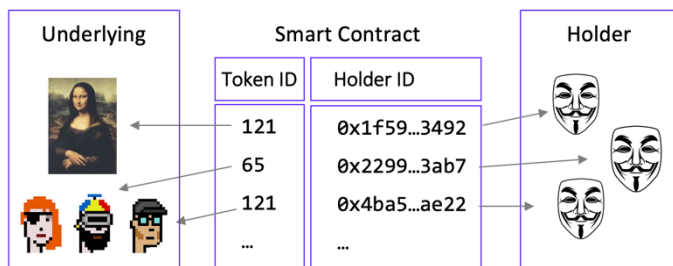
Figure 1: An NFT associates underlyings with holders, providing a record of ownership of those underlyings.

Ownership

NFTs have started to define the standards of digitised ownership of digital and analogue items. As stated above, an NFT represents the claim of ownership over an underlying.

It is important to look into how a claim of ownership is tied to the underlying (Figure 1). As for most NFTs, the underlying exists outside the blockchain, and having the ownership claims enforced can be nuanced and complex.

For example, an NFT representing ownership of a patent could mean that any proceeds from the usage of that patent should be forwarded to the owner. But the NFT could not effectively enforce any restrictions on its usage.

Transfer

A transfer takes place between the current owner of the NFT to a new NFT owner. In the smart contract, the digital identifier associated with the current holder is replaced by the digital identifier of the new person, entity or machine. The ability to transfer tokens through a predefined framework is a core function of an NFT.

The transfer process in the token smart contract can also include further operations and conditions.[1]

Uniqueness

An NFT is often associated with the uniqueness of the underlying it refers to.[2] Both, the smart contract and the digital identifiers of the owner and the underlying are guaranteed to be unique by the blockchain. It is important to note that as of right now, these guarantees are limited to the blockchain. NFTs face a non-uniqueness risk. They cannot ensure that the underlying they refer to is not a copy of another, e.g. the same digital artwork stored in two different files. Additionally, a truly unique underlying

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[1] One possible application can be the transfer of the stream of income associated with a patent from the current NFT holder to the new NFT holder.

[2] An NFT should be seen as a unique representation of ownership rather than a proof of uniqueness of an underlying itself.
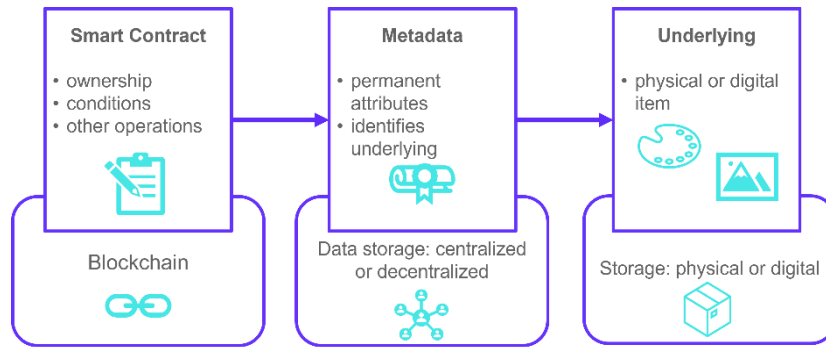
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Figure 2: Technical components of an NFT.

could be referred to by different tokens.[3]

While ownership, transfer and uniqueness show the *idea* behind NFTs, we need to look closely at the technology in order to understand its benefits and limitations.

Technical anatomy of NFTs

An NFT consists of three main technical components: the Smart Contract, the Metadata and the Underlying. These components and how they are connected can be seen in Figure 2.

The **Smart Contract** is a piece of chaincode that is deployed on a blockchain such as the Ethereum public blockchain. The smart contract implements a registry that associates the identifier of the holder[4] with a unique identifier of the underlying, and is responsible for the representation of the ownership, or encoding the conditions for the transferability. It can also encode other operations such as the distribution of royalties or proceeds from transfers. Further it provides the location of the Metadata.

The NFT **Metadata** identifies the underlying. The NFT Metadata can be stored on a cloud service or on a decentralized storage service such as IPFS (Interplanetary File System)[5], which provides for the immutability of the Metadata over time.

The NFT **Underlying** is the underlying item/data/right etc. owned through the NFT. As discussed above, it usually exists outside of the blockchain. Digital items can be either stored by a cloud provider or in a decentralized storage solution.

State of the art implementations

The first NFTs (e.g. RarePepe) were issued on the Bitcoin blockchain. Nowadays, standards for NFTs are usually defined for the Ethereum blockchain. The two most popular and standardized tokens are the ERC-721[6] and ERC-1155[7]. Due to Ethereum's high transaction costs and limited transaction throughput, other blockchain solutions are emerging such as Flow, Polygon and Solana.

Potential limitations and risks

Due to their anatomy, NFTs are based on different technology layers. This entails risks, in particular:

- Non-uniqueness risk: The NFT does not guarantee for the uniqueness of its underlying. Trust in the issuer[8] to guarantee uniqueness is still required, that it ensures the consistency of the NFT across its three layers.
- Copyright enforcement risk: The NFT itself does not enforce copyrights on the underlying.[9] However, clever storage and access systems can be setup to successfully enforce these copyrights. One approach is to tie ownership (digital identifier of the owner) to the right to access the underlying.[10]
- Storage risk: Quality of storage is decisive for the longevity of NFTs. The loss of the underlying would lead to the NFT being worthless, whereas the loss of

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[3] The token smart contract is itself unique within the blockchain it is deployed in. This however does not prevent different tokens to be refer to the same underlying.

[4] Usually, a so-called blockchain address

[5] In many NFTs, Metadata and Media Data are stored in IPFS. This is a decentralized data storage network, resistant to tampering and censorship, but public.

[6] ERC-721 was the first standardized interface for creating NFTs. It's the most widely used. It can't be divided and represents a single asset that is in interchanged. It's appropriate for

creating and tracking single unique NFTs, but less appropriate for tracking and transferring collections of NFTs.

[7] ERC-1155 is a unique token that supports non-fungible (NFTs) and fungible tokens. It's faster and more efficient to use in batch token transfers.

[8] Identity of issuer should thus be known

[9] Many digital art NFTs are publicly available.

[10] See VideoCoin for an example

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Metadata would destroy the NFT by disconnecting the smart contract from the underlying.

NFTs are exposed to similar risks as other digital assets. These could result in the total loss of the NFTs:

- Private keys can be lost or be a target of cyber attacks
- Technical bugs in the token smart contract or the asset storage layer

Some of the above can be resolved by regulatory structures, others by appropriate technological standards and business best practices.

The regulatory framework around NFTs

Current regulation of NFTs mainly focuses on their role as (financial) assets.

The introduction of new regulation, such as the Markets in Crypto-asset regulation (MiCA) and FATF travel rule have laid the ground for a legal framework in the crypto space. Due to their non-fungibility, NFTs are however different from the classic understanding of crypto-assets.

The scope of the aforementioned regulatory frameworks is ambiguous when it comes to NFTs. But, unique and non-fractionable NFTs will most likely not be regulated as crypto-assets under EU and FATF definitions.

To tackle regulatory uncertainty regarding NFTs, we recommend addressing the notion of ownership. This could mitigate some risks associated with NFTs, such as the copyright enforcement risk. Giving NFT Smart Contracts the required legitimacy can furthermore result in easier enforcement of ownership rights.

Conclusion & Outlook

While NFTs find more and more wider adoption, we see NFTs still being in their early development stages. Many questions remain unanswered with respect to the technology as well as at the regulatory level.

One reason for this is the plethora of use cases with different underlyings from regulated and non-regulated markets, as well as the sprectrum of retail and institutional NFT buyers. Another reason is that it is not always clear what the ownership of the token represents, or which parts are enforced by the technology, and which require a look at the legal context. Given that innovation in the space is progressing at a fast pace, and the attention the topic has received, we see the potential for many of these problems to be tackled.

For the same reasons, a "one-fits-all" NFT-regulation, which disregards the specific nature of the underlyings and the rights represented by an NFT, would not provide for a reasonable and proper regulation. This should be considered in the upcoming MiCA negotiations.

Finally, we see large potential in NFTs that exceed the the most well-known applications: digital art or gaming. Whether it will be the digitization of patents or other ownerships of intellectual property or tracking of ownership to reduce fraudulent activity, NFTs have the potential to redefine ownership in a digital day and age. Current developments even show the usage of NFTs as collateral in the Decentralized Finance space, increasing the incentives for buying and holding NFTs.

Appendix: Example with digital art

To better understand our analysis of NFTs, we describe a well-known use case: digital art where the underlying is a picture.

NFT / Asset	Consists of the Underlying and the Smart Contract.
Token Smart Contract	Registers the owner (blockchain address) and identifies the underlying though the metadata. Can have additional function, such as forwarding revenue income streams to the creator's blockchain address.
Underlying	A digital picture stored in the cloud. The file is publicly accessible and can be stored or distributed separately.
Metadata	Stores the URL of the picture, creator, timestamp of creation, or others
Risks	The uniqueness and scarcity, and therefore value, are guaranteed by the technology and the issuer. The issuer is crucial to the value of the NFT. No copyright claims can be enforced by the token; therefore, it is important for the buyer to understand what he is purchasing, and for the artist/creator to understand the limitations of the medium.
Rights	Unless stated otherwise in a legal contract, the token holder has the rights enforced by the smart contract and those only: the ownership of the NFT.

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