A Survey of Blockchain: from Theory to NFT Applications

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Abstract:

The blockchain technology that has emerged in recent years has the characteristics of distributed ledgers, immutability, traceability, programmability, and security, providing new ideas and opportunities for the development of the digital economy. Non-Fungible tokens, due to their immutability and decentralization based on blockchain, have brought new trading models to the digital encryption industry and have had a significant impact on the recognition rights of digital assets. So this article introduces the basic concepts and characteristics of Non-Fungible tokens and blockchain, discusses the impact of blockchain on Non-Fungible tokens, introduces the properties, protocols, and ecosystems of Non-Fungible tokens, and finally looks forward to the future development trends of Non-Fungible tokens.

Keywords —**Non-Fungible tokens,Blockchain,Digital copyright,Decentralization, Digital Asset Management**

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I. INTRODUCTION

The emergence of blockchain technology has brought a revolutionary change to the field of digital assets[1-2].The digital assets of the world on the chain have attracted people's attention[3].Non-Fungible tokens(NFT),as one of the important applications of blockchain technology,are gradually attracting global attention and discussion. Unlike traditional Cryptocurrency,NFT is the only and non interchangeable digital asset. They record on the blockchain with unique identifiers,and ensure that their ownership,authenticity and Scarcity are verified.This makes NFT an ideal choice for trading and holding various virtual or physical items such as art,music, and game props in the digital field.

By combining NFT with blockchain,we can solve many of the problems we have faced in the past, such as identifying the authenticity of artworks, ensuring copyright ownership, and avoiding the circulation of counterfeit goods.In addition,when it is difficult to establish a trust mechanism in the Wet market,the decentralized platform built on the blockchain can provide a more fair,transparent and secure trading environment. This article will provide a brief introduction and explanation of blockchain and Non-Fungible tokens, followed by a description of typical application scenarios, problems and risks faced,and finally a prospect of their future development trends.

II. BLOCKCHAIN

A. Overview of BlockChain

Blockchain technology originated from the groundbreaking paper "Bitcoin: a point-to-point Electronic cash system" published by a scholar with the pseudonym of "Satoshi Nakamoto" on the Cryptography group in 2008[4]. Blockchain is a distributed ledger that contains time-stamped records organized intoblocks, which are interconnected by repeating a hash code as the first part of one block and the last part of the previous one[5].The data structure of blockchain is shown in Figure 1. In other words, a blockchain is a database on a distributed network, where participating nodes can back up data. To protect data from tampering, the ledger is shared with all nodes on the network, which is one of the characteristics of blockchain.
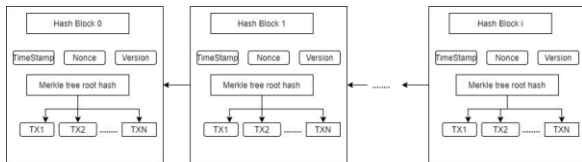

Fig. 1 A simple BlockChain

B. Blockchain Architecture

The blockchain system consists of a data layer, network layer, consensus layer,incentive layer, contract layer, and application layer.Among them, the data layer encapsulates the underlying data blocks and related basic data and algorithms such as data encryption and timestamp;The network layer includes distributed networking mechanisms, data dissemination mechanisms, and data verification mechanisms;The consensus layer mainly encapsulates various consensus algorithms of network nodes;The incentive layer integrates economic factors into the blockchain technology system,mainly including the issuance and distribution mechanisms of economic incentives; The contract layer mainly encapsulates various scripts, algorithms, and smartcontracts, which is the foundation of the programmable features of blockchain;The application layer encapsulates various application scenarios and cases of blockchain.

III. NON-FUNGIBLE TOKENS

A. Definition of NFT

NFT, short for non-fungible tokens [6], are digital or physical assets that possess unique identification codes to distinguish them from one another.Unlike traditional cryptocurrencies such as bitcoin or ether, which are fungible and have dentical value per unit, NFT are distinct and irreplaceable.This non-fungibility means that each NFT holds its own individual worth and cannot be equal to another.Furthermore,NFT can not be divided or combined[7].These exceptional characteristics contribute to the uniqueness and special properties of NFT.The core elements of Non-Fungible tokens are shown in Figure 2.
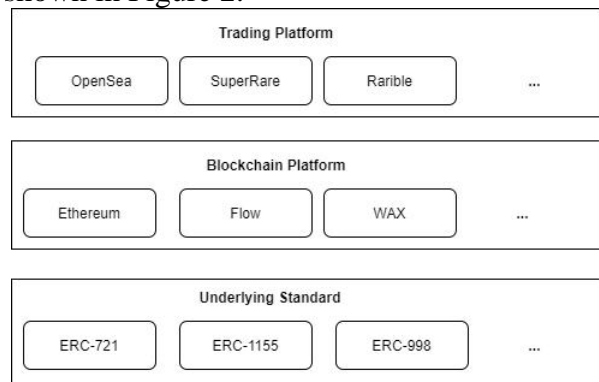

Figure 2.The core elements of NFT

B. Bottom Level Standards

At present,there are three main standards for NFT, namely ERC-721,ERC-1155,and ERC-998[8].

1) ERC-721: ERC-721 is the first standard of NFT,which was proposed by Ethereum in 2017 and is also a commonly used underlying standard.Its first application is the CryptoKitties project.It is proposed for the requirements of assets with unique attributes, representing the ownership of assets.Under this standard,each token is unique and indivisible, therefore each token has different value,and its complete circulation and transaction process will be recorded on the blockchain,which can be viewed by anyone,making the ownership transfer process of each NFT under this standard traceable.

2) ERC-1155: ERC-1155 differs from other NFT standards in that it allows for the simultaneous management of multiple different types of tokens in a smart contract.Using ERC-1155,developers can create a separate smart contract to manage multiple asset types.These assets can be unique, irreplaceable, or digital items with custom attributes and functions. This standard introduces two main concepts: ID and balance. Each asset is assigned a unique ID, and each address can have a balance corresponding to a specific type of asset with that ID. In addition, ERC-1155 also provides batch operation methods, allowing users to more efficiently perform multiple ransfers, queries, and other operations.It also

supports atomic transaction execution and on chain event notification mechanisms, enabling tighter integration between applications and tokens.

3) ERC-998: ERC-998 establishes a new universal protocol between ERC-721 and ERC-20.This standard allows multiple NFT to be combined into a single tradable set. The traditional NFT standard can only represent independent and indivisible assets, while ERC-998 introduces the concept of "partial ownership",allowing users to nest existing NFT into other NFT. This can create a more complex and hierarchical structure and provide greater flexibility for digital artwork, game props and other cenes. With ERC-998, users can extend existing assets by adding children or additional items. Each child is an independent and transferable entity that inherits the attributes of its parent and may have its own unique attributes. This nested relationship makes complex objects and systems possible, and provides more creative space for creators and developers.

IV. APPLICATIONS

A. Digital Copyright

The open, inclusive and Sharing economy development characteristics of the The Internet Age have promoted rapid economic growth and provided new space for the digital economy.In this context,Non-Fungible tokens (NFT) have emerged and provided new application practices for protecting digital copyright.In the past, there was a lack of unified and standardized copyright certification services in the field of digital content, resulting in a large amount of asymmetric information in copyright transactions.This makes it difficult to fairly distribute copyright profits to original authors and third-party institutions. However,NFT are registered and minted on decentralized and open blockchains, using a unique approach from traditional token standards such as ERC-721 to mark ownership of native digital assets. Based on this technological foundation, NFT can provide better solutions for digital copyright protection.Using NFT, projects related to copyright issues such as artworks, music, patents, etc. can be represented by different and unique NFT, and utilizing the characteristics of blockchain distributed ledgers such as tamper resistance, decentralization, and public storage to achieve unchanging identification and property registration of digital products. In addition, traceability enables original authors to track their ownership, thereby achieving the purpose of copyright protection.

B. Financial Sector

NFT can convert various assets in the real world (such as art, real estate, collectibles,etc.) into digital form and use blockchain technology to ensure their uniqueness and authenticity.This makes traditional financial markets easier to access and trade.Individuals or institutions can have unique ownership certificates, which are not interchangeable.This provides a higher level of transparency and security for the financial industry. The decentralized trading platform based on smart contracts on the blockchain(such as the DeFi project on Ethereum)can promote the purchase, sales and liquidity of NFT.In this way, investors can directly trade with other holders without the need for third-party intervention, reducing costs and increasing flexibility.Decentralized finance (DeFi), established on the basis of the ERC-721 standard,naturally exists in Non-Fungible tokens.NFT have the potential to become collateral for loans and the currency itself, allowing them to serve as digital assets and achieve the same loan collateral capabilities as physical physical assets. However, it remains to be discussed whether they will have value for the entire financial ecosystem.NFT can serve as the foundation for financial derivatives, such as creating tradable digital copyright certificates, revenue rights certificates,or other complex financial products. This helps to provide more diversified and flexible investment choices.

C. Gaming

The application of NFT in the gaming field can provide players with unique, traceable, and clearly owned virtual items.By using NFT,game developers can create rare items, characters, or equipment and sell or trade them as digital assets. This allows players to truly own and control the virtual items they purchase, and enjoy the benefits of ownership both inside and outside the game. At the same time,NFT also gives players more autonomy and flexibility to transfer and share virtual items they hold between different games.In addition, since each NFT is unique and traceable,they can also serve as a tool for documenting important data such as identity, achievements, or honors.In summary, NFT has opened up new possibilities in the gaming

industry.They have changed the restrictions on the ownership and circulation of virtual items in traditional game modes, and provided players with a more immersive and personalized experience.

V. CHALLENGES AND OPPORTUNITIES

A. Traceability

Blockchain can provide a decentralized and tamper proof ledger to record and verify the ownership and creation time of digital content.By storing copyright information on the blockchain, unauthorized copying or theft can be prevented. Firstly,due to the decentralized nature of blockchain,any copyrighted work no longer requires thirdparty authentication,supervision, and management in the future,abandoning the traditional cumbersome offline path and institutional authentication,and being directly supervised by the entire network,greatly saving the costs of copyright owners and management and registration agencies.Secondly,after the digital work is uploaded, the registration platform will stamp it with a timestamp, and at the same time, calculate the content hash value and write it into the blockchain through a hash algorithm.Time stamps are the temporal information of data content and important evidence to prove the existence and order of data.

B. Automatic Execution

A smart contract is a program running on a blockchain that can detect the state of the blockchain network and spontaneously execute the agreed terms.Smart contracts are based on blockchain technology,and all transactions and operations are recorded in tamper proof distributed ledgers.This means that digital copyright information can be completely and openly saved, and cannot be modified or deleted without authorization.At the same time,due to the automatic implementation of the contract,Digital rights management has become decentralized,and no single entity can independently determine and control the use rights of the works.This decentralized structure can provide a more fair and transparent approach to copyright management. With the help of smart contracts, artists, creators, and other stakeholders can interact and trade

directly without relying on traditional media or third party platforms as intermediaries.This reduces costs,reduces transaction friction,and provides more direct copyright control and revenue distribution mechanisms.

C. Unified Standards

The NFT craze has attracted public and academic attention,providing common development expectations for different blockchain ecosystems. Unlike traditional art transactions, although NFT works have complete traceability capabilities, there is still a risk of economic damage after being recast or segmented.Due to the lack of market legal regulation,there may be similar transaction performance on different public chains.Therefore, it is urgent to establish unified value evaluation and identification standards in the overall operation of the industry.To ensure the uniqueness of digital asset ownership and transaction security, consensus mechanisms,industry standards,Value judgment mechanisms,identification methods and online identification mechanisms need to be established on different public chain ecosystems.

D. Illegal Activities

The issue of the rule of law in NFT has gradually become a focus of attention. Due to the fact that NFT can represent digital assets such as artworks, music works,etc.,these digital assets often involve intellectual property rights such as copyrights, patents, or trademarks. Therefore, when using NFT for transactions,it is necessary to ensure that the digital assets involved comply with relevant national or regional intellectual property regulations and have clear authorization or licensing.Secondly, there may be fraudulent behavior and false advertising issues in the non homogeneous token market.Due to the uniqueness and irreplaceability of NFT,there may be cases of counterfeiting or stealing others' works for sale in the market.Therefore,establishing effective regulatory mechanisms to prevent fraudulent behavior is crucial.

VI. CONCLUSIONS

NFT, with its unique digital characteristics of indivisibility, irreplaceability, and ownership, achieves alternating changes in ownership of digital

assets, real-time tracking, and value maintenance. NFT has a revolutionary impact on the digital economy. By creating scarce encrypted assets and promoting the trend of digital capitalization, NFT, together with New Infrastructure technologies such as blockchain, artificial intelligence and Big data, has accelerated the arrival of the digital society.

While looking forward to existing NFT technologies and applications,we also need to carefully evaluate and conduct research.Although NFT has opened up new directions for economic development, traditional illegal and criminal activities such as money laundering and fundraising still exist. Therefore, it is necessary to strengthen research in NFT infrastructure, classification systems,application scenarios,and value recognition to promote the formation of a universal and stable NFT ecosystem.

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