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Digital Copyright Protection Based on Blockchain Technology

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ABSTRACT. In the digital age, there are still many problems with centralized digital copyright protection technology. The decentralization, traceability, scalability, and data transparency of the blockchain provide new ideas for digital copyright protection. This paper summarizes the application of blockchain technology in the field of digital copyright protection, and expounds its advantages and disadvantages, and provides suggestions for the application of blockchain technology in the field of digital copyright protection.

Keywords: digital copyright protection, blockchain, digital rights management, decentration

1. **Introduction.** With the rapid development of Internet technology and digital content, sharing and creation have become people's daily life, and the popularity of social media and smartphones has made more people become content creators. Digital content such as music, software, games, pictures, videos, and texts are widely traded and disseminated through the Internet. At the same time, the traditional copyright protection mechanism has been difficult to adapt to the copyright protection requirements of digital content in the new era. The online digital content infringement incidents continue to occur, and the digital content on the Internet has infringement and piracy problems. While using and disseminating digital content, users intentionally or unintentionally disseminate copyrighted and valuable resources, consume potential user resources, and damage the economic interests of creators and related rights holders. Digital copyright protection has become a key and difficult issue.

To protect digital rights, there are currently many Digital Rights Management (DRM) systems on the market.[1] The current DRM is a centralized registration type, which is a centralized copyright management mechanism authorized by an authoritative management organization. Although most DRM technologies have certain protection effects, they have been repeatedly cracked. At the same time, as a centralized copyright management mechanism, DRM technology often limits the sharing of digital content, and even eventually becomes a tool for merchants to monopolize profits, which makes users resentful and conflict.

Blockchain technology provides new ideas for digital copyright protection, and the unchangeable decentralized copyright registration form has become a new choice for digital copyright protection. Under the blockchain technology, the results of digital copyright generation and transaction recording, transmission and storage are all credible, and the recorded information cannot be tampered once it is generated.

This paper summarizes the development of blockchain technology and the development of digital copyright protection; and it focuses on the digital copyright protection based on blockchain technology, hoping to contribute to the research of digital copyright protection technology.

2. Blockchain Technology. In 2008, the scholar of the pseudonym Satoshi Nakamoto published a groundbreaking paper "Bitcoin: A Peer-to-Peer Electronic Cash System" in the cryptography mailing group. [2] The blockchain technology originated here. Broadly speaking, blockchain technology is a new decentralized infrastructure and distributed computing paradigm which uses cryptographic chained block structures to validate and store data, distributed node consensus algorithms to generate and update data, and automated scripting code (smart contracts) to program and manipulate data. [3]



FIGURE 1. BLOCKCHAIN DATA STRUCTURE

Each data block in the blockchain contains a block header and a block body. The block header encapsulates the current version number, the previous block address, the target hash value of the current block, the solution random number of the current block PoW consensus process, the Merkle root, and the timestamp.[3] Many of the features of the blockchain technology determine its applicability to digital copyright protection, and it is particularly advantageous in terms of copyright registration.

1) Decentralization

Traditional databases are centrally deployed in the same cluster and managed and maintained by a single organization. The blockchain is decentralized. There are no central nodes, which are managed and maintained by multiple participants. Each participant can provide nodes and store data on the chain, enabling fully distributed inter-party information sharing. [4]

2) Traceable

The blockchain uses a time-stamped chained block structure to store data. In this way, the time dimension is added to the data, making it verifiable and traceable. [3] Each change in the data is recorded on the blockchain and any changes to the data can be tracked. The blockchain guarantees irreversible modification of the data based on Merkle trees and blockchain tables. All node data is transparent and transparent. [4] After reaching a consensus, the information recorded in the blockchain cannot be tampered with.

3) Expandable

The digital copyright protection system based on blockchain technology has sufficient robustness and flexibility. In different usage environments, the blockchain can be forked out of the new version according to different copyright transaction needs. [5] The horizontal scalability makes the overall performance of the distributed database linearly increase as the number of cluster nodes increases. [4]

4) Data transparency

In a decentralized blockchain network, nodes are jointly provided and maintained by multiple participants. Under the consensus mechanism, each new transaction is broadcast to all nodes of the blockchain network. The public chain allows any node to join the network, allows any user to participate in the transaction, and the entire ledger data is transparent. [4]

3. **Digital Rights Management (DRM).** After 1994, with the popularization of the Internet and the development of digital technology, especially the development of peer to peer technology, there are more and more digital content on the Internet, and piracy problem is becoming more and more serious. [6] The traditional copyright protection method can no longer meet the needs of digital content copyright protection. Then the digital rights management (DRM) have been proposed.

Digital rights management technology refers to the technical tool for copyright management in the process of generating, distributing, selling and using digital works. Its purpose is to protect the intellectual property rights of digital content throughout the life cycle through technical means to ensure the legitimate use and dissemination of digital content. DRM is a combination of many technologies such as digital certificates, encryption, digital watermarking, public/private keys, authentication, access control, and rights description. [7]

3.1. Current Major Digital Rights Management (DRM) Technologies. At present, there are many digital copyright protection technologies. The paper mainly introduces several key technologies, including digital watermarking technology, public Key Infrastructure (PKI) technology, digital fingerprint technology and electronic signature and authentication

technology. All of these methods can protect the copyright of digital products to some extent, and they are also common methods of copyright protection of digital products.

1) Digital watermarking technology

Digital Watermarking is a kind of information hiding technology. The basic idea is to embed information in digital products such as digital images, audio and video to protect the copyright of digital products. [8] It should be noted that when adding a digital watermark to a digital product, it is necessary to maintain the original content of the product as much as possible, that is, it should maintain invisibility, also known as fidelity. Other basic features of digital watermarking include security, robustness, and the like. At present, digital watermarking technology mainly includes image watermarking, audio watermarking and video watermarking.

2) Public Key Infrastructure (PKI) technology

PKI is a key management platform that adheres to strict standards. Based on key theory and technology foundation, it is a set of hardware, software, personnel and applications based on public key algorithm. It should have the ability to produce, manage, store, distribute, and abolish certificates. [9] Public key cryptography provides security through public-private key pairs and encrypts information using encryption keys. Relying on the algorithm function to generate two different but mathematically related complementary "asymmetric cryptosystems" of "public key" and "private key", it is difficult for others to infer the private key by the public key under the control of a reliable asymmetric cryptosystem, which is how this technology protects the copyright. [10]

3) Digital fingerprint technology

Many digital content security issues are often caused by internal leaks. In digital copyright protection, users often transmit digital content and lead to its second spreading. In response to this problem, digital fingerprint technology was proposed. Digital fingerprinting is the embedding of user-related information in digital content. It could track leakers based on digital fingerprints embedded in electronic documents. The main technologies of digital fingerprinting include fingerprint encoding, fingerprint protocol and fingerprint hiding. To a certain extent, its ability to detect leaks can prevent the illegal behavior of the leaker. [11]

4) Electronic signature and authentication technology

An electronic signature is not a digital image of a written signature but an electronic code. It is generally believed that electronic signatures refer to the use of symbols and codes to form an electronic password for "signature" instead of writing a signature or sealing. For electronic signatures, authentication is also required to issue certificates. The third party that performs the certification is generally an electronic certification service. In addition to technical realization, electronic signature technology requires the protection of the legal system and requires a certain social structure to cooperate with it. [12]

4. **Digital Copyright Protection Based on Blockchain.** Decentralization technology can solve many problems in traditional DRM. For DRM systems, this decentralization refers to both technical decentralization and decentralization of the economy institutions. [13] A

centralized DRM system is often controlled or operated by a company or organization. If the organization or company has operational problems, the DRM system will also fail. In the short term, natural disasters, cyber-attacks and regime changes will all lead to problems. Decentralized digital copyright protection under blockchain technology can avoid such problems.

4.1. **Related Research.** Herbert and Litchfield [14] use blockchains for software license verification. The author defines two blockchain forms in license verification. In the Master Bitcoin Model, consumers prove ownership by proving that they have bitcoin from a software vendor. The Bespoke Model is a master bitcoin model with additional data fields that allows software manufacturers to store license information (such as license expiration). Custom models are used for individual users with a single license. The next work plan for the study is to allow users to hold hundreds of licenses.

McConaghy and Holtzman [15] use the Bitcoin blockchain to record image ownership. Legal registry storage terms and time stamps. The registry is stored in a blockchain with ownership information. Web crawlers use machine learning to detect images placed on a website without the owner's permission.

Kishigami et al. [16] describe a blockchain based content distribution system. The system uses a blockchain to manage rights for 4k video, allowing copyright holders to manage content licenses, including removing user licenses for content. The system does not allow offline viewing of content, and its client needs the online miner's transaction ID to decode the content.

Gao and Nobuhara [17] proposed a method for storing up to N*20 bytes in a blockchain. For creators of output digital files that do not want timestamp anonymity, the method can embed hashes of electronic data and related information (such as file name, author name, comment). Comments and other related information can be written in plain text. This method creates a transaction with N output addresses instead of inserting data into the OP_RETURN field. Therefore, each transaction can store up to N*20bytes. Due to the blockchain data expansion problem, the method sets N=3 and conducts experiments to evaluate the proposed method and verify the existence and integrity of the digital file. The author of digital documents can protect the existence to prove their work. For ordinary users, the content stored in the specific transaction can be found and restricted by the rights in the copyright information. The method needs to be further improved to apply to other intellectual property rights and patent protection.

4.2. The Existing Blockchain Digital Copyright Protection Projects. On the blockchain digital copyright protection, entrepreneurs have made unremitting efforts and attempts. The following is a brief introduction of several existing blockchain digital copyright protection projects. Meanwhile, there are many attempts at blockchain-based digital copyright protection schemes, such as art chain (Yilian), Binded, Monegraph, Everledger, and so on. Due to space limitations, they are not listed here.

1) Ebookchain

Ebookchain is a decentralized digital publishing platform that uses blockchain

cryptographic signature technology and time stamps to achieve copyright protection. Incentives are built through a new generation of cryptocurrencies encourage sharing and collaboration. Using sidechain technology to achieve third-party development seamless integration, a variety of decentralized applications are developed, and thus it created a three-dimensional ecosystem and a one-stop publishing platform. [18]

2) Bitgene

The Bitgene blockchain is a decentralized digital content protection, trading, tracking and advertising value-added system. Bitgene is committed to using innovative, patented technology on the blockchain to link digital genes to digital genes that are hard to detect but can be recognized by applications for identification. It enables authentication, trading, tracking, and advertising of digital content in a variety of online and offline scenarios. [19]

3) Mediachain

Mediachain uses the IPFS (Interplanetary File System) file system to protect copyrights of digital works. Currently, it is mainly for digital image copyright protection applications. Mediachain is a collaborative federated media metadata protocol that provides copyright recognition for innovative works, and copyright owners sign metadata statements with cryptographic signatures. The blockchain timestamps declared in the distributed ledger are stored in IPFS. These claims can be obtained by searching. [20]

4) Xiright (Xiaoxi Blockchain)

The Copyright Guardian Infringement Monitoring Platform is an Internet copyright monitoring system developed by Xiaoxi Intelligent. It aims to provide copyright owners with accurate copyright usage data, screen unauthorized use, and provide powerful data analysis for copyright rights. Evidence curing service. Relying on Xiaoxi Intelligent's data analysis system, file comparison algorithm and blockchain deposit certificate system, copyright guards can provide automatic infringement monitoring services for copyright owners, simplifying the difficulty of forensics and improving the timeliness of forensics. [21]

5) Ujo Music

Ujo uses Ethereum for music release. Ujo uses Imitation Heap's "Tiny Human" to release the artist's payment. It uses the Ethereum blockchain to pay for the artist, manage the identity of the artist, and uses the Interplanetary File System (IPFS) to transfer data. [22]

5. Blockchain-based Digital Copyright Protection Technology Advantages and Limitations. Compared with the current digital version protection technology, blockchain-based digital copyright protection technology is very advantageous, but at the same time, there are many problems and limitations. Some problems in digital copyright protection still cannot be solved at present.

5.1. Advantages of Blockchain Digital Copyright Protection. Blockchain digital copyright protection has advantages of low cost, high security and high transparency. The decentralized storage mode and chain block structure of blockchain enable it to meet the demand of digital copyright protection.

1) Low cost

Under the centralized digital copyright protection mechanism, information circulation costs are large, and it is often in a state of high cost and low operational efficiency; all data is stored in a centralized organization, which increases maintenance costs. [23]

The digital copyright system based on the decentralized structure of the blockchain can save operating costs and improve operational efficiency while ensuring information security. At the same time, the transaction between the two parties in the system also eliminates the intermediary process, solves the intermediary credit problem, and saves intermediary costs.

2) High security

Current DRM systems often encounter cracking problems, and the centralized data storage structure makes them less risk-resistant.

Blockchain technology replaces the traditional data center concept by using decentralized storage, using distributed concepts, so that data security identification does not have to be done in the data center, but on different nodes of the network, which improves the security of the system. Make digital content copyright information difficult to tamper with. [24]

3) High transparency

Most of the existing RRM technology research and development is characterized by excessive attention and protection of the interests of publishers and publishers, while ignoring the rights and interests of ordinary users. Many of the technologies and new technologies in development have been used to control and supervise the information of ordinary users, and their privacy issues are not fundamentally guaranteed.

The blockchain uses a time-stamped chained block structure to store data. In this way, the time dimension is added to the data, making it verifiable and traceable. [3] Each change in the data is recorded on the blockchain and any changes to the data can be tracked. The blockchain guarantees irreversible modification of the data based on Merkle trees and blockchain tables. [4] All node data is transparent and transparent. After reaching a consensus, the information recorded in the blockchain cannot be tampered with, or all changes to the data information will be left with modification marks.

5.2. **Problems and Limitations.** Although the block digital copyright scheme has unique advantages, there are many problems. At the present stage, the digital copyright protection based on blockchain technology lacks policy and legal support and it has great technical difficulties. The blockchain is insufficient in data storage capacity, and its processing capacity is low for mass data. At the same time, there is a shortage of relevant talents.

1) Lack of policy and legal support

Technology applications can only be sustained in the long run if they are incorporated into the national legal framework. If the data records of the entire Internet are dispersed in different blockchain systems, and there is no direct authentication and identification between them, automatic marking, identification and protection on the whole network cannot be realized. The current practice is to introduce authoritative copyright certification bodies in the alliance chain, such as the National Copyright Protection Center, notary offices, law firms and various associations, to jointly maintain the credibility of the blockchain copyright platform ecosystem. [25] The promotion of digital copyright in blockchain is inseparable from the cooperation of copyright management agencies. Only when the government introduces relevant policies to support the attempt and development of blockchain in the field of digital copyright protection can we really introduce blockchain as a tool in traditional copyright authentication.

2) Technical difficulty

Blockchain technology is a comprehensive architecture that integrates various advanced technologies such as network programming, distributed algorithms, cryptography, and data storage technologies. It requires cross-disciplinary talents. The technical difficulty is large, and the training time of relevant talents are long and the high-level talents are extremely scarce, which limits the development of the industry. [26]

3) Insufficient data storage capacity

The blockchain-based digital copyright protection technology is often saved into the blockchain by making an encrypted ID with OP_RETURN or CoinSpark. However, according to the Bitcoin protocol, the maximum data capacity allowed for each transaction of the OP_RETURN built-in code is 40 bytes, so it is unrealistic to store more data in the blockchain, which is not conducive to large-scale application of copyright protection.[5] Using a customized distributed ledger to directly bind the data of the work to each transaction, the security is not guaranteed in the short term, and the capital cost and time cost of establishing the copyright protection mechanism are relatively high. At the same time, the blockchain technology also faces data expansion problems. The blockchain needs to store one copy of data at each node for backup, but as the data increases, the technical requirements for storage space will become higher and higher. [23]

4) Low processing capacity

The digital copyright protection scheme based on blockchain technology cannot cope with large-scale transaction data and interactive traffic, and needs to further optimize the underlying protocol and expand the application layer development. The blockchain is characterized by information transparency and openness. However, the broadcast of blockchain messages also consumes a large amount of underlying network bandwidth, and even leads to a decline in network performance. The network computing power also consumes a large amount of power resources. [23]

6. **Conclusions.** For digital works, traditional copyright registration requires high capital and time costs. On the one hand, the blockchain-based digital copyright protection technology is characterized by its security and credibility, which can record all links, decentralization, less time spent on registration, and low cost. However, at present, most research is still stuck in the theoretical stage, and the technical theory needs to be met. Urgently, many technical problems cannot be solved, and there are also legal recognition and certification issues. In the current environment, the blockchain still needs to be in contact with national institutions, and it still needs credibility to endorse. In addition to the right to confirm, in the protection of rights, the blockchain cannot judge the infringement.

On the other hand, the development of national standards and regulatory policies can

provide a good internal and external environment. According to the "2018 Pan-Entertainment Industry White Paper" released by the Industrial Economic Research Institute of the Ministry of Industry and Information Technology, the blockchain is changing the basic industry model of digital copyright trading and income distribution mode, user payment mechanism, etc., which will form the whole industry chain value sharing platform of copyright owner, producer, issuers and users. [27]

At present, the development and application of domestic blockchain is still at an early stage. Talents are scarce; blockchain infrastructure is imperfect; and the blockchain industry is in the stage of gradual exploration. At the same time, under the current copyright operation mode, the contradictions in various aspects are not prominent. However, with the advent of the Internet era, digital copyright issues urgently need innovative blockchain technology, and digital copyright protection technology based on blockchain has broad prospects for development.

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