



A Design of Digital Rights Management Mechanism Based on Blockchain Technology

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Abstract. Digital rights management (DRM) has been widely used in digital content protection nowadays and has made a great contribution to the protection of digital content. However, the traditional DRM technology has several disadvantages such as centralization, non-transparency of copyright information and transaction information. Centralized servers are vulnerable to be attacked and opaque information is not user-friendly. The blockchain technology which has emerged in recent years has the advantages of decentralization, collective maintenance, security, and reliability. It can be a great solution to the above problems. In this paper, we propose a design of DRM Mechanism based on blockchain technology. We record the copyright transaction information and license information on the blockchain to make information transparent and safe. We use smart contract to ensure the reliability of copyright transaction and issue licenses automatically, which eliminates the need for centralized servers to verify identities and issue licenses. Our mechanism allows copyright owners to set prices for different content usage rules as they wish. Customers choose the usage rules they would like to purchase flexibly. We also design a blockchain based license structure, which is close to the current DRM standards and easy to be promoted.

Keywords: DRM · Blockchain technology · License · Transaction Smart contract

1 Introduction

With the rapid development of internet technology, the global information process is promoted continuously. The application of information technology has been expanded to all the fields, so that digital content can spread quickly and widely all the time. Due to its openness, digital features, content is facing a significant risk of being malicious disseminated, copied, tampered at any time, which has led to higher demand for digital rights management. Digital Rights Management (DRM) [9] refers to the realization of system solutions through the use of information security technology to ensure legitimate users' normal use of digital content. It also protect the legitimate income of producers and owners of

digital media content. After the copyright infringement problem occurs, it can identify the authenticity of the copyright information and make a correct determination of copyright ownership. Many international organizations and companies have formulated DRM standards and these DRM standards have made a great contribution to protecting digital rights.

However, traditional DRM technology have several disadvantages because of its centralization. First of all, the transaction of copyright is supported by centralized server, and the issuing of licenses needs centralized server too. Once the centralized server is attacked, the service is in a great risk of paralysis. Secondly, the specific information of copyright and transaction is not public to users so it is not transparent. Individual content producers must sell their content to large video site or media platform to seek for DRM protection. What's more, the identities in traditional DRM technology need to be verified through multiple interactions, which is cumbersome and inconvenient.

To solve the problems above, the blockchain technology is an excellent choice. Blockchain technology is the core supporting technology of digital cryptocurrency system represented by Bitcoin. It originated from the foundational paper published by Satoshi Nakamoto in 2008 [1]. Blockchain is a kind of decentralized shared ledger that assembles data blocks into specific data structures in a chain manner in chronological order and it guarantees irreversibility and unforgeability in a cryptographic way. Blockchain uses encrypted chain block structures to validate and store data, uses distributed node consensus algorithms to generate and update data, and uses automated script code to program and manipulate data. Blockchain has decentralized, time-sensitive data, collective maintenance, programmable, secure and trusted features. In terms of the application of blockchain technology, Bitcoin realized a payment method which does not require any third-party financial institution for the first time. Ethereum [2] added smart contracts based on electronic cash technology, making both financial and non-financial agreements intelligent. There are many applications and platforms [3–5] based on blockchain technology that devote to making blockchain technology step into our lives.

The purpose of this paper is using the decentralized, safe and credible characteristics of blockchain technology to improve the traditional DRM technology so as to make up for the technical defects mentioned in the previous article. The contribution of this paper is as follows: (1) We record copyright transactions on the blockchain to make the transaction information safe, reliable and transparent. We have designed a mechanism that allows copyright owners to set prices for different content usage rules flexible. Consumers are free to choose the purchase rules they use. At the same time we use smart contracts to ensure the reliability of the transaction. There is no need for interactive information between copyright owners and consumers. The blockchain technology based DRM mechanism we proposed provides a more credible means of protecting copyrights for individual content producers, and the authorization of copyrights is also extremely scalable. (2) Our license information is recorded on the blockchain, and the license information is safe and transparent as well. We use smart contracts to issue

licenses automatically. In this way, we eliminate the need for centralized servers to issue licenses, and also eliminate the need for interactive verification between user and server identities. We simplify the process. (3) We designed a license structure suitable for blockchain, which can be used for automatic packaging and distribution of licenses by smart contracts. At the same time, the designed license structure is close to the current DRM standards, which is beneficial to the promotion of this blockchain-based license structure.

The rest of this paper is organized as follows. Section 2 presents the related works, mainly contains blockchain technology, DRM, and the application of blockchain technology in DRM so far. Section 3 describes the design of license, whereas Sect. 5 describes the design of DRM mechanism based on blockchain technology. The conclusions and future work are in Sect. 6.

2 Related Works

2.1 Blockchain Technology

Blockchain technology is considered to be the fifth type of disruptive innovation as a successor to mainframes, personal computers, the Internet, mobile/social networks [10]. Its features contains decentralization, time-series data, collective maintenance, programmability, security and reliability, etc. In the distributed system where nodes do not need to trust each other. Blockchain technology achieves point-to-point transactions, coordination, and operations. Thus it provides solutions to the problems of high costs, inefficiency, and insecure data storage that exist in centralized organizations. Blockchain technology is the embryonic form of the next-generation Internet. The existing Internet is just an information Internet. Without the centralization of banks and other institutions, the exchange of value cannot be achieved. The next-generation Internet, achieves not only the information communication, but also the value communication, and the cornerstone is blockchain technology. Blockchain technology is expected to achieve a transformation from the current information Internet to the next generation of value Internet, which will completely reshape the human social activities just like what the information Internet has made. The characteristics of blockchain technology make it widely used in digital cryptocurrencies, financial systems, and social systems. Innovative technologies have been used in the financial, medical, education, and Internet of Things fields to solve key issues in the industry. For example, filecoin [6] is a decentralized storage network that turns cloud storage into an algorithmic market which combines blockchain technology and IPFS [7] technology. It provides a good choice for file secure storage. MedRec [8] is a novel decentralized record management system to handle EMRs, using blockchain technology. Their system gives patients a comprehensive, immutable log and easy access to their medical information across providers and treatment sites.

A smart contract is an instance of a computer program that runs on a blockchain which has a unique address. Any user can create a contract by publishing a transaction to a blockchain. Once a smart contract's program code has

been created, it cannot be changed and will be executed whenever a message from a user or other contract is received. The behavior of the contract is determined by the publisher while receiving a message. Smart contract can read and write stored files, send messages to other users or contracts. It can also deposit currency into the account balance or send it to other users or contracts. The terms of contracts cannot be changed. Therefore, contracts cannot be changed. The principle of smart contracts is shown in Fig. 1.

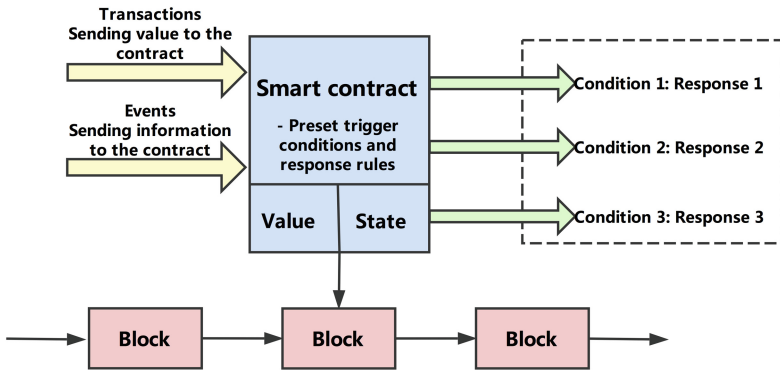


Fig. 1. Smart contract working principle

In this paper, we make use of the security and reliability features of the blockchain technology. We record copyright transaction information and license information on the blockchain, making the information safe and trustworthy. We use smart contracts to issue licenses automatically and also use smart contracts to ensure the reliability of copyright transactions.

2.2 Digital Rights Management

Digital rights management (DRM) [11, 12] is a type of management system developed to enable secure distribution, and more importantly, to disable illegal distribution of paid content. DRM technologies are being developed as a means of protection against the online piracy of commercially marketed material. The high-level architecture and major components of a typical DRM system are shown in Fig. 2.

To ensure a great security of digital content, international organizations and companies have formulated many DRM standards. Open Mobile Alliance released the OMA DRM 1.0 standard officially in November 2002 [13, 14]. OMA DRM is mainly designed for mobile data services and fixed data services, and it has been updated to version 2.0 now. Marlin DRM was introduced by the United States Intertrust company in 2005, co-founded with four other companies: Panasonic, Sony, Philips and Samsung [15, 16]. The goal of Marlin DRM

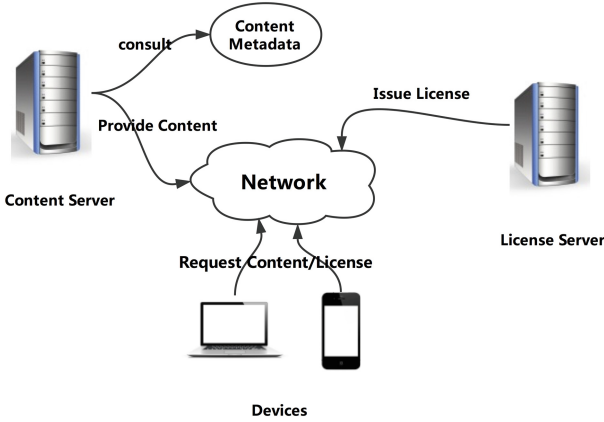


Fig. 2. High-level architecture and major components of a typical DRM system

is to implement a DRM system compatible with a wide range of consumer electronic devices. Google spent heavily to buy the video digital rights management software company Widevine in December 2010 [17]. Widevine DRM helps Google make up for the shortcomings in digital copyright protection and helps Android become the dominant mobile OS today. CCTV and Tsinghua University established China DRM Forum in November 2004 with the support of The State Administration of Radio Film and Television (SARFT). The forum aims to promote the development of DRM in China and protect the rights and interests of every participant in the digital content industry chain to build a sound environment for the development of digital content [18].

DRM has made great progress in the world. However, the traditional DRM technology has several disadvantages because of its centralization. Centralized servers are vulnerable to be attacked and opaque information is not user-friendly. The blockchain technology is thought to be a good solution for these disadvantages. Since the emergence of such a great technology as blockchain, there has not been a set of proper DRM mechanisms combined with blockchain technology. This paper has made an attempt. We hope to promote the development of DRM mechanisms based on blockchain technology. The license structure we proposed is close to current DRM standards, which is beneficial for the promotion of this blockchain-based license structure.

2.3 DRM Based on Blockchain Technology

There have been several papers make tries on combining DRM with blockchain technology. Xu et al. [19] proposed a network media's digital rights management scheme based on blockchain. They hope to provide an important support for the network media platform to build a sustainable development of benign ecological environment. But they only record the transaction information on the blockchain and ignore the copyright information, which makes the design incomplete. The

blockchain they used is private blockchain which is not decentralized completely. Fujimura et al. [20] propose a concept for a new rights management system based on the blockchain technology, and clarified problems that occur when they applied the blockchain technology to the rights management system. They record the copyright information on the blockchain, but the transaction between copyright owners and consumers occur out of the blockchain, which means we need a central institution to ensure the copyright purchasing. This feature makes the decentralization not complete. The mechanism proposed in this paper avoids the disadvantages of the above papers. We record both copyright transaction information and license information on the public blockchain. On the one hand, we use the smart contracts to ensure the reliability of copyright purchasing, and record the transactions on the blockchain. We don't need any central institution. On the other hand, we make use of smart contracts issuing licenses automatically, and record the licenses on the blockchain. In this way, both the content providers and the consumers could query and verify the copyright information at any moment, and furthermore, no one could tamper the copyright information.

3 Design of License

We make use of smart contracts issuing licenses automatically. After the content provider sets the price of the content according to the rules, the consumer who wants to purchase the content makes price estimation according to his own needs. Then the consumer sends information to the smart contract to purchase. The contract will package the license according to the needs of the purchase and send it to the consumer account.

3.1 License Structure

License consists of elements such as content, authorized accounts, rights, key, key usage rules, and hash values, which is shown in Fig. 3(a).

When the license is issued, it is composed of the license indexing unit and one or more subsequent basic units. All the units except the indexing unit are basic units. The elements described in the logical structure of the license are described as below:

- (1) License Indexing Unit: The license indexing unit is the first unit of the license. The license indexing unit includes the version, license ID, and basic unit number. The license ID is the unique identity of a license. The basic unit number is the number of basic units.
- (2) Content: Content is a digital thing, such as pictures, text, audio, video, etc. The license stores a unique identifier for the content, contentID.
- (3) Authorized Account: The authorized account is the owner of the rights to the specified content. It is the account of the consumer who purchased the copyright in the blockchain.
- (4) Rights: Rights refer to the rights of using content, such as playing, storing, etc.

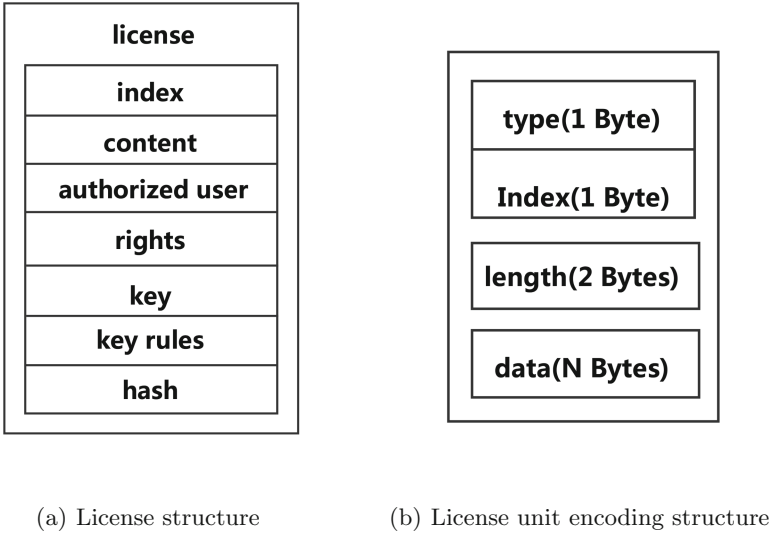


Fig. 3. License

- (5) Key: The key refers to the key information contained in the license, such as the encryption algorithm and key data. The key data is encrypted by the consumer’s public key and can only be decrypted with the consumer’s private key.
- (6) Key usage rules: Key usage rules define how consumers can use keys, including the start time, the end time, time period, number of times and other relevant rules. The license is generated in the form of a purchase chosen by the consumer, and the consumer can only use the key according to the rules.
- (7) Hash: The hash refers to the hash of all previous units and is used to verify the integrity of the license data. When consumers receive a license, they should check the hash first.

3.2 License Unit Encoding Structure

Both the license indexing unit and the basic unit in the license are composed of three parts: unit identification, length, and data. The unit encoding is as shown in the Fig. 3(b).

The unit identification consists of 2 bytes, including the type and index. The first byte is the type, and the second byte is the index of the unit in the license, which is used to support the segmented transmission of the license. The length section is the length of the actual data information of the unit and is represented by two bytes. The data section is the actual data of the unit and is represented by N bytes.

4 Copyright Transaction

The content providers and the customers can choose to be a peer of our blockchain or choose to link to one trusted peer our blockchain platform provides. The peers need to be listening to messages from the smart contract all the time. The copyright transaction is shown in the Fig. 4.

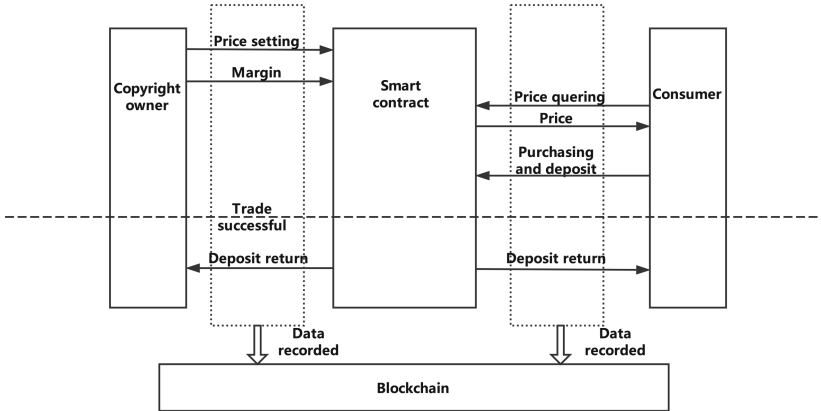


Fig. 4. Copyright transaction

4.1 Price Settings

We have designed a flexible license authorization system that allows copyright owners to set a price for their content. As the license structure mentioned in Sect. 3.1, the rights and key usage rules are designed for authorization. The copyright owners can set the price of the rights for their content, such as the price for playing the content, the price for storing the content, etc. They can also set the price corresponding to the key usage rules for their content. For example, the content can be used by time, number of times, or time period, etc. Corresponding to different key usage rules, copyright holders need to pass different parameters to the smart contract. If they want contents to be used by time, the copyright owners need to set the price required by the unit time. To be used by the number of times, the copyright owners need to set the price for each time. To be used by the time period, the copyright owners need to set the time period and the price corresponding to this time period. The price between the right and the key usage rules is in additive relation. The copyright holder's setting of the price will be written into the transaction information between the node and the smart contract, so that it will be written into a block and recorded in the blockchain.

When consumers choose to purchase a product, they search for the optional rights first and key usage rules corresponding to the content through the smart

contract. Then they need to choose the rights and key usage rules according to their own needs. The smart contract will return the price to be paid. After the consumers have paid successfully, the smart contract will package and send the licenses to the consumers automatically according to the demand. Among them, consumer information such as content inquiries and purchases, as well as license information sent by smart contracts, will be written into the transaction information between the nodes and the smart contract, which will be written into a block and recorded in the blockchain.

In this way, buyers and sellers can trade flexibly according to their interests. At the same time, all trading information and copyright information are recorded in the blockchain, and both sides can check at any time. The use of smart contract also eliminates the direct interaction between copyright owners and consumers.

4.2 Trade Pledge

Copyright trading is guaranteed by smart contracts. When a copyright owner publishes his content to a smart contract, he will pay a certain amount of deposit. This deposit ensure that the trade can be proceed smoothly. The copyright trader can add deposit to his account at any time. Consumers are required to pay a 5% premium over the content price when choosing to purchase the copyright of a content. After the license is sent to the consumer and checked successfully, the consumer will feed back information that the content can be consumed successfully to the smart contract. At this time, the smart contract will return the 5% deposit of the content price to the buyers and sellers of the trade. In this way, we can ensure the reliability of the trade. Once one side destroys the trade, the deposit will not be returned to this side. With the support of blockchain technology, trades guaranteed by smart contracts are safe and credible.

5 Design of Blockchain-Based DRM Mechanism

5.1 Blockchain-Based DRM Mechanism Prototype

Figure 5 shows the blockchain-based DRM mechanism prototype. Content providers, consumers, and advertisers use blockchain clients to interact with nodes. Nodes are responsible for basic functions such as interaction with smart contracts and blocks production. The digital content can only be used by the client. The rules and keys used are obtained from the license. This avoids the fraudulent use of digital content.

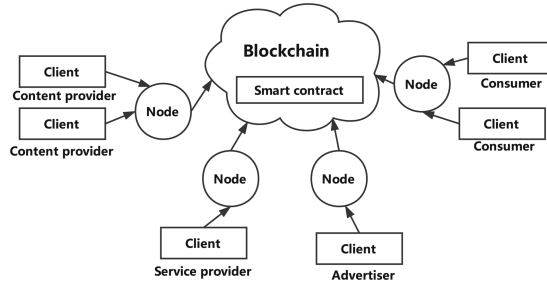


Fig. 5. Blockchain-based DRM mechanism prototype

5.2 DRM Mechanism Process

The business process of the blockchain-based DRM mechanism is shown in Fig. 6.

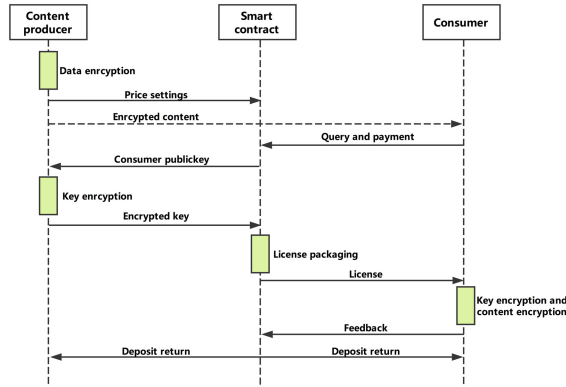


Fig. 6. The business process of the blockchain-based DRM mechanism

- Step 1* A content producer encrypts the digital content and obtains the encrypted data and key data. Then the content producer keeps the key data for the follow using.
- Step 2* The content producer, also called as copyright owners, interacts with smart contracts to set the price of the corresponding content rights and key usage rules.
- Step 3* A consumer obtains the encrypted content he wants to use through an off-chain way. The consumer can obtain content through a centralized video site, or through a peer-to-peer network such as IPFS.
- Step 4* The consumer interacts with the smart contract to find out how he/she can use the content and how much he/she have to pay for their needs. Then the consumer chooses the rights and the key usage rules he/she would like to pay.

- Step 5* The smart contract sends the consumer's public key information to the content producer. The content producer uses the consumer's public key to encrypt the key data which was used to encrypt the content, and sends the encrypted key data to the smart contract.
- Step 6* The smart contract packages the index, content, authorized accounts, rights, keys, key usage rules and hash together, according to the rights and key usage rules chosen by the consumer, as the way mentioned in Sect. 3.1. Then the smart contract sends the license to the consumer.
- Step 7* After the consumer obtains the license, the consumer uses his private key to decrypt the encrypted key data according to the key encryption algorithm. Then the plaintext of key data is obtained. At this time, the consumer could use the key to decrypt the encrypted content to get the plaintext of content.
- Step 8* The consumer feedbacks the message to the smart contract that the license can be used correctly. Then the copyright transaction is completed. The buyer and seller's deposit is returned to their respective accounts. The entire blockchain-based DRM process is completed.

5.3 Storage Management

Storage management mainly consists of three parts:

- (1) Copyright Trading and License Information Storage: In essence, blockchain is a distributed database that can be used to store and transmit dispersed data. When we implement the DRM mechanism based on blockchain technology, we can store copyright transaction information and license information on the blockchain. In this way, users can check their transaction records and authorization information or authorized information at any time. Moreover, because this information is stored on the blockchain, it also has features that cannot be tampered with forgeries. The block structure is shown in Fig. 7. With using the hash chain and time signature technology, we can build a proof of these data. The license on the smart contract is temporarily stored in a part of the memory of the smart contract after being assembled. After the license's being sent to the consumer, the occupied memory is released.
- (2) Content storage: After the content producer completes content creation, the content producer encrypts the content to obtain the encrypted content data, content ID and key. The encrypted content data is stored on a centralized video site or on a decentralized peer-to-peer network for consumers' downloads. The key is stored by the content producer himself, waiting to be encrypted with the consumer's public key later. Content IDs are published by content producers on smart contracts for consumers' inquiries.
- (3) Account information storage: Both content producers and consumers need to register accounts on the blockchain platform, and need to store certain virtual currency in the account to complete subsequent copyright transactions. The smart contract stores the account information by mapping. The accounts are divided into two categories. The content producer's account

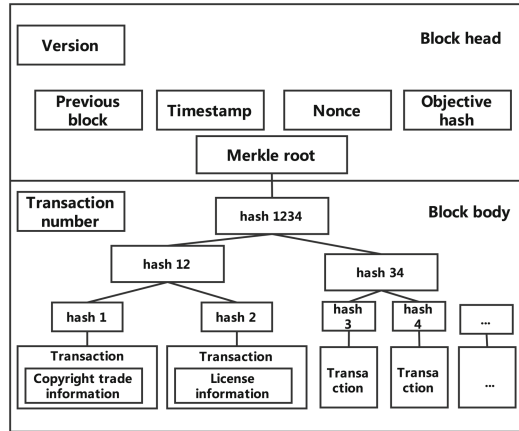


Fig. 7. Block structure

needs to store information such as address, virtual currency balance, content ID, price settings, and so on. Consumer accounts need to store virtual currency balances, public keys, addresses, and so on.

5.4 Copyright Information Management

Recording copyright information on the blockchain enables low-cost copyright confirmation of digital content. Individual content creators can publish content on the blockchain that implements our DRM mechanism easily. So that they don't have to sell content rights to a large media company or a media platform. Content creators can price their own content flexibly, set copyright rules for their content, and gain greater autonomy. At the same time, copyrights are recorded on the blockchain and cannot be tampered, which also solves the problem of copyright disputing fundamentally. Consumers can view published content and price information at any time, and purchase copyrights according to their interests for content using. Once the copyright is purchased, both buyers and sellers cannot make changes. Consumers don't need to worry about the fact that the purchased copyright will be tampered with or cancelled. The information in the blockchain is transparent.

Large online media platform can also add copyrighted digital products on the blockchain under our new DRM mechanism too. With blockchain technology, the platforms can track and monitor the use of copyright. At the same time they can record the consumer's user behavior and analyze the data to find out which products are more popular with consumers and introduce more high-quality digital products. The most important thing is that the decentralized blockchain systems are harder to be broken than the centralized servers.

We believe that the blockchain-based DRM mechanism can make the living environment of digital content more fair and more harmonious. Due to the con-

venience and permanency of copyright confirmation, we can also develop more application scenarios such as the copyright notarization, crowdfunding, certificate authentication and so on.

5.5 Transaction Management

We record all the information that users interact with smart contracts on the blockchain, including the content publisher's releasing information on the content, the price setting information on the content copyright use rules, the consumer's inquiry on the content price, the consumer's purchase of the digital content on the preference, and the smart contract feedback margin information. These transaction information is recorded in the blockchain to ensure that transactions can be tracked and queried at any time. Once the transactions are created, they will be broadcasted on the blockchain network. The nodes in the blockchain create blocks for these transactions and calculate the block's hash. The node that acquires the right to credit will link the new block to the blockchain, thus saving the information permanently. Using blockchain to record transaction information can greatly reduce transaction costs and improve transaction efficiency. Each node can view and check all transaction information at any time. The blockchain's consensus algorithm ensures that records cannot be forged. The blockchain's digital signature technology also reduces fraudulent transactions. This kind of management can achieve efficient and secure transactions and thus promote the healthy development of digital content protection environments.

5.6 Potential Business Benefits

Using the proposed blockchain-based DRM mechanism model, we can reasonably coordinate the relationship between content providers, service providers, consumers and advertisers. Firstly, content providers, both individual content creators and content production companies, have a clear understanding of how much consumers love their content. Secondly, smart contracts ensure the unforgeable nature of transactions and copyright information, and consumers will feel comfortable using them. For service providers, blockchain technology gives value to digital content. For example, if a digital content only sells 10,000 copies, the lifecycle of each content can be tracked using blockchain technology. The owner of the licenses can be queried on the blockchain, we could also provide transfer function of license, so that the digital content has a collection of meaning. For advertisers, using our model can clearly see the number of digital content using with advertisement, so as to know the effectiveness of advertising. They do not have to doubt the authenticity of the data, so that advertising costs the value for money they paid. We believe our model will provide a healthy development environment for the production, dissemination and consumption of digital content.

6 Conclusion and Future Work

In this paper, we designed a new DRM mechanism based on blockchain technology. We use the decentralized, safe and credible characteristics of blockchain technology to make up for the shortcoming of centralized traditional DRM technology. We record copyright transactions and license information on the blockchain, which makes them safe, reliable and transparent. At the same time we use smart contracts to ensure the reliability of the transaction and the issuing of licenses. There is no need for interactive information between the copyright owner and the consumer, and we don't need centralized license server to issue licenses either. In this way, we simplify the process and save the costs. The license structure based on blockchain technology we proposed is close to the current DRM standards, which is suitable for promotion.

One defect of our work may be the peers of our blockchain platform have to be high-powered to deal with high concurrent key acquisition. We will work to solve or weaken this problem in the future. The future direction of this work is the realization of this new blockchain based DRM mechanism. Considering the need for high concurrency, we plan to make a try on EOS blockchain for the first time. We will test the performance of this new mechanism and improve the performance. Then we aim to promote this new DRM mechanism for a better protection of digital content.

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