# Research and Application of Copyright Protection of Ethnic Cultural Resources Based on Blockchain

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**Abstract.** The mobile Internet has changed the way of copying and spreading cultural works, copying and spreading them quickly in a low-cost way, resulting in increasingly serious infringement problems. At present, the traditional copyright management system has some problems, such as difficulty in confirming rights, high cost, low efficiency and low security of data storage. The emergence of blockchain technology provides a new idea for copyright protection. Blockchain technology can accurately, timely and completely record a series of processes such as the generation, use, transaction and transfer of digital copyright, solve the problems of digital copyright confirmation and transaction, and also provide support for the tracking of infringement. Therefore, by studying the theory and application of blockchain in the field of copyright, and taking the local representative cultural faction resources in Qinghai as a breakthrough, this paper puts forward a method to realize copyright registration, registration and transfer by using Hyperledger Fabric blockchain and intelligent contract, and to realize copyright storage of digital works by using IPFS, so as to build a copyright protection system for ethnic cultural resources, which takes advantage of the decentralized, unchangeable and traceable features of blockchain. Provide credible and effective online copyright protection services for national cultural resources, enhance the production value of national cultural industries, and provide strong support for copyright protection of national cultural works.

**Keywords:** Fabric blockchain; IPFS interstellar file system; Copyright protection; Qinghai ethnic cultural resources; Decentralization

## 1 INTRODUCTION

With the rise of digital cultural works, copyright has become a bottleneck that restricts the further development of the digital content industry. The constraints of copyright on the development of the digital content industry are mainly reflected in the following three aspects: firstly, the process and subject of copyright transactions are very complex, and the dissemination chain and ownership of copyright are very vague; Secondly, copyright authentication comes at a high cost. The high cost of copyright registration has led to some authors not registering their copyrights, thus providing opportunities for infringement; Thirdly, copyright infringement cases have long trial cycles and high

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litigation costs. Various influencing factors have led to a lack of proper management and protection of digital content copyright, while also suppressing the innovation and originality of the digital content industry, which to some extent restricts the development of the social and cultural industry[1]. Therefore, copyright protection is a prerequisite for the healthy development of the digital content industry and a necessary condition for the production of high-quality cultural works.

At present, most traditional copyright protection methods still remain in the stage of relying on third-party organizations for copyright management. Third party organizations usually adopt centralized databases to store copyright information. On the one hand, these databases are vulnerable to attacks, which can cause the storage of copyright information to be compromised[2]. On the other hand, centralized storage corresponds to centralized management rights. Individuals with management rights have absolute rights to make changes to the database and view content, which can easily lead to adverse events such as information leakage. At the same time, the rise of the Internet has changed the storage and transmission methods of various cultural works, making the traditional copyright protection methods unable to meet the needs of digital content copyright protection [3,4,5]. Qinghai is a region of multi-ethnic, multi religious, and multicultural integration and coexistence. For thousands of years, all ethnic groups have worked together on this land to produce, live, and coexist harmoniously, creating a long and brilliant history of civilization. Colorful ecological tourism cultural resources, unique folk cultural resources, rich ancient cultural resources, rich religious cultural resources, and rich ethnic folk art and cultural resources have intertwined, forming a unique, ethnic rich, and diverse ethnic culture in Qinghai. On the basis of a comprehensive review of Qinghai's ethnic cultural resources, studying the theoretical issues, protection mechanisms, and technical means of protecting excellent ethnic cultural resources has become an urgent need for the creative transformation and innovative development of Qinghai's ethnic culture.

Zhang[6] and J Xuehua[7] proposed a copyright protection method for digital works based on digital watermarking. Convert the information of the copyright owner into digital watermarks, print the digital watermarks into the copyrighted works, and when copyright infringement occurs, the digital watermarks embedded in the copyrighted works will also be copied together, which can serve as crucial evidence in the pursuit of infringement; R. Mehta [8] proposed using a hash algorithm to calculate the hash value of an image file as the unique identifier of the image, and storing it in the blockchain. There are other methods to extract the overall features of the image as the basis for copyright; Similarly, Shi et al. [9] proposed an image copyright protection system based on blockchain and SIFT. The SIFT algorithm and perceptual hashing algorithm are similar in that they both determine the similarity between images by calculating their hash values. The main feature of the SIFT algorithm is to search for key points and locate feature directions in different scale spaces of the image [10].

In summary, there are three difficulties in the current methods of image digital copyright protection[9]:

The emergence of blockchain technology, characterized by decentralization, extremely difficult tampering, traceability, programmability, and security and trustworthiness, provides a solution to the current problems in the field of digital copyright

protection. Firstly, decentralization is the most significant technological advantage at the beginning of blockchain development. The verification, accounting, storage, maintenance, and transmission of blockchain data are all based on a distributed system architecture, using pure mathematical algorithms instead of central institutions to establish trust relationships between massive untrusted distributed nodes, achieving peer-to-peer transactions, coordination, and collaboration based on decentralized trust. This provides a new solution for solving the common problems of high cost, low efficiency, and insecure data storage in centralized systems; Secondly, it is extremely difficult to tamper with. Blockchain technology is a way for everyone to participate in bookkeeping, jointly record and store transaction information, and jointly maintain transaction databases. Therefore, it has the characteristics of being extremely difficult to tamper with, undeniable, and unforgeable. Among them, immutability and non repudiation refer to the inability of anyone to modify or deny transaction data once a consensus is reached through verification and written into the blockchain. Unforgeability refers to the inability of anyone to forge transactions verified by miners through effective means, let alone forge the entire transaction change record. Compared to traditional centralized databases, blockchain utilizes the one-way nature of hash functions, the anti-counterfeiting authentication function of digital signatures, and the fault-tolerant ability of distributed consensus, greatly increasing the difficulty and cost of attackers maliciously tampering, forging, and denying data operations; Thirdly, traceability. The blockchain adopts a chain blockchain structure with timestamps to store data, thereby adding a time dimension to the data, which has strong verifiability and traceability. Timestamps can serve as proof of the existence of blockchain data, which not only helps to form an immutable and unforgeable blockchain database, but also records each change in transactions on the blockchain in chronological order, which is correlated before and after, making it easy to retrieve the entire change process from the release source to the latest state of the transaction. This feature lays the foundation for the application of blockchain in time sensitive fields such as notarization and copyright protection; Fourthly, programmability. Blockchain technology can provide a flexible script code system, supporting users to create advanced smart contracts or other decentralized applications; Fifth, safety and trustworthiness. Blockchain technology uses asymmetric cryptography to encrypt sensitive information of all parties involved in transactions, and only authorized nodes can access or use it; At the same time, with the help of cryptographic tools such as zero knowledge proof and homomorphic encryption, as well as the powerful computing power formed by consensus algorithms of distributed nodes, blockchain data can be guaranteed to have high security and effectively protect user privacy[11].

## 2 RELATED WORK

### 2.1 Blockchain technology

Blockchain technology originated from Nakamoto's groundbreaking paper "Bitcoin: A peer-to-peer cash system" in 2008[12]. Blockchain is a continuously growing list of blocks linked using cryptographic methods. Each block contains the cryptographic hash

value, timestamp, and transaction data of the previous block (usually organized in the form of a Merkel tree). Blockchain can prevent data tampering and is an open and distributed ledger that efficiently records transactions between two parties in a verifiable and persistent manner.

In 2016, Yuan Yong and Wang Feiyue first proposed the "six layer model" of blockchain infrastructure in reference[13]. Generally speaking, a blockchain system consists of a bottom-up 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 data encryption and timestamp technologies; The network layer includes distributed networking mechanisms, data propagation 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 smart contracts, which is the foundation of the programmable features of blockchain; The application layer encapsulates various application scenarios and cases of blockchain. In this model, timestamp based chain block structure, distributed node consensus algorithm, economic incentives based on consensus computing power, and flexible programmable smart contracts are the most representative innovative points of blockchain technology.

## 2.2 Hyperledger Fabric

The Fabric in the Hyperledger project was led by IBM to create an alliance chain dedicated to open source specifications and standards for blockchain technology. The super ledger adopts a modular architecture system, allowing developers to freely combine pluggable identity authentication management, consensus mechanism, encryption algorithm and other components on the platform according to their needs, thereby breaking through network processing bottlenecks, greatly improving scalability, and meeting commercial level business needs. Compared to public chains, alliance chains represented by super ledgers emphasize the value and collaborative relationships between institutions or organizations within the same industry or across industries, and have advantages in performance, capacity, privacy, isolation, and scalability. They are an important development direction for blockchain in the future.

The overall architecture of the Super Ledger Fabric is shown in Figure 1, which includes multiple components such as applications, ledgers, chain codes, blockchain structures, databases, consensus, permission management, digital certificates, and network layers.

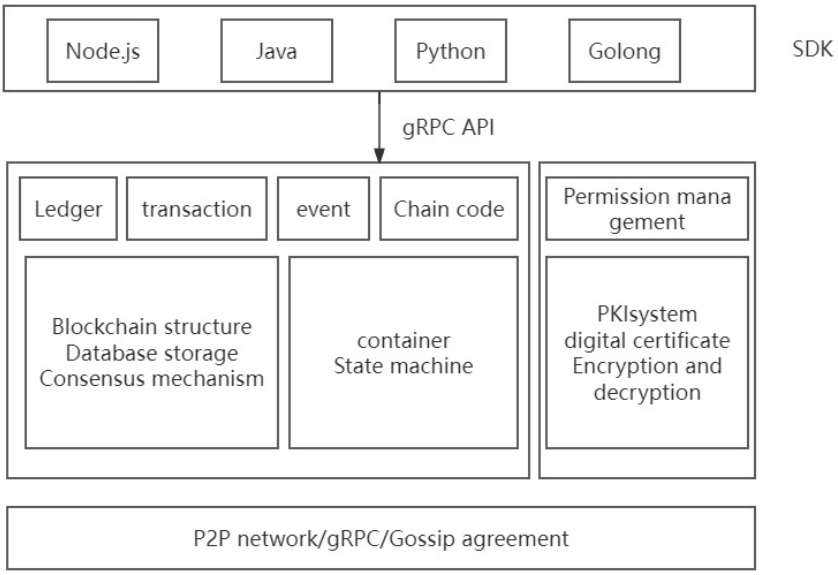


**Fig. 1.** Overall architecture diagram of Fabric

## 3 ARCHITECTURE DESIGN OF COPYRIGHT PROTECTION SYSTEM FOR ETHNIC CULTURAL RESOURCES

This article designs and implements a blockchain based copyright protection system for ethnic cultural resources. The system uses the Fabric blockchain platform as the underlying technology, utilizing its features of decentralization, immutability, traceability, and low cost to achieve copyright information registration, query, certification, and transfer; At the same time, design similarity analysis algorithms based on representative ethnic cultures in Qinghai to ensure the originality of registered content; And use the IPFS interstellar file system to store the registered images and their feature content. The copyright protection platform for ethnic cultural resources based on blockchain technology is a system proposed by us to address the lack of copyright protection for ethnic traditional culture. Its overall structure is mainly divided into six parts:

Front end display layer: The front end display layer is mainly a copyright protection system for ethnic cultural resources based on blockchain technology. It is mainly aimed at cultural resource providers, cultural and creative workers, institutions, or individual consumers. The advantage of our front-end display layer is that it can meet the needs of different ethnic cultural creators.

Functional application layer: The functional application layer is mainly divided into two parts, one is the cultural resource information query subsystem, and the other is the cultural resource copyright trading and transfer subsystem.

Core competency layer: The core competency layer mainly refers to the main capabilities of our platform, including how to manage, protect, and trade the copyright of ethnic cultural resources, and how to build a blockchain based copyright confirmation process mechanism and smart contract trading mechanism.

Data resource layer: The data resource layer mainly involves modeling and digitizing ethnic cultural works, summarizing them, and constructing a database.

Basic Business Layer: The basic business layer mainly includes the following modules: log/report system, authentication/authentication center, user management system, and interface management system.

Basic system layer: Develop high availability components for copyright protection based on blockchain technology. Based on the underlying foundation of blockchain, including distributed network architecture, blockchain networks, and consensus algorithms, research is conducted on security protection technologies for blockchain characteristic cultural copyrights, including trusted on chain technology, property rights confirmation technology, regulatory technology, infringement storage technology, and on chain data privacy protection technology.

# 4 DISTRIBUTED STORAGE OF IMAGE COPYRIGHT FEATURES BASED ON IPFS

## 4.1 Storage Design of Image Copyright Protection System

There are many advantages to using IPFS for storage: IPFS systems have lower storage costs; IPFS is based on content addressing, where hash values correspond one-to-one with files, making access more efficient; IPFS only produces the same hash value when the file content is the same, greatly reducing resource redundancy. In order to improve the utilization of cyberspace, most Fabric based applications choose to use the Fabric blockchain platform to store transaction information, the IPFS system to store other information, and the IPFS hash value to map between the two[14].

## 4.2 Working principle of storage system

1) When each file containing image copyright features is uploaded to an IPFS node, a unique encrypted hash value is calculated based on its content. This hash value directly reflects the content of the file. Even if only one bit is modified, the hash value will be completely different, making it difficult for files stored on the IPFS network to be tampered with, ensuring high security of the file.

2) The data stored in IPFS is permanent. Even if the network node is revoked, the file can still be accessed normally. The more peer network nodes in IPFS, the higher its reliability.

3) When searching for files, IPFS is requested based on the hash value of the file, which retrieves the file through the hash and verifies whether it is the correct data using the hash value.

# 5 IMPLEMENTATION OF A COPYRIGHT PROTECTION SYSTEM BASED ON FABRIC AND SMART CONTRACTS

## 5.1 Transaction processing process

Based on the different characteristics of workloads in different stages of the transaction lifecycle, Fabric divides nodes within the network into three categories: CA nodes, Orderer nodes, and Peer nodes. Peer nodes correspond to all accounting nodes within the channel on the editor, and some Peer nodes can also play the role of Endorsers. This type of role division allows different types of nodes to focus on handling their respective businesses. A typical transaction processing core process includes five main steps, in which each component performs different functions throughout the entire transaction process[15].

Client creation request: The client application uses SDK to interact with Fabric networks. Firstly, the client obtains a valid identity certificate from the CA in order to join the application channel within the network. Before initiating a formal transaction, it is necessary to first construct a transaction proposal and submit it to the Endorser for endorsement. After collecting sufficient endorsement support (determined by endorsement strategy), the client can use endorsements to construct a legitimate transaction request and send it to the Orderer for sorting processing. The client can also listen to messages in the network through event mechanisms to determine whether transactions have been successfully received.

Endorser node endorsement: mainly provides the ProcessProposal method for clients to call and complete the endorsement (currently mainly signature) processing of transaction proposals. After receiving the transaction proposal from the client, the first step is to conduct a legality and ACL permission check. If the check passes, the transaction will be simulated and the status changes caused by the transaction will be endorsed, and the result will be returned to the client.

The Committee node updates the ledger: responsible for maintaining the blockchain structure and database. This node regularly obtains sorted batch transaction block structures from the Orderer or leader node, and performs final checks on these transactions before closing. After passing the inspection, write the execution results of legitimate transactions into the ledger, construct a new block, update the Blockmetadata metadata in the block, and add legitimacy tags.

Orderer sorts nodes: Orderer globally sorts all legitimate transactions in the network and combines the sorted batch of transactions to generate a block structure. Orderer does not need to deal with transaction content.

CA manages identity certificates: Referring to the PKI architecture, responsible for managing all certificates in the network. Implemented in a separate fabric ca project. After issuing the certificate, CA itself does not participate in the transaction process in the network. After these steps, transactions in the network are consensus and recorded in the ledger, and no node can overturn or tamper with transaction history.

### 5.2 Design of Digital Image Copyright Smart Contract

Smart contracts are a breakthrough innovation in blockchain. It can be seen as a program deployed on the blockchain that can run automatically. It can obtain data information from external sources. When the conditions set by the program are met, the system will trigger the automatic execution of corresponding contract terms, realizing a series of functions such as data processing, value transfer, and asset management. In a blockchain system, every call made by a user to a smart contract (or chain code) is called a transaction. Users can call the contract and perform corresponding operations by calling the function interface provided by composer test serve.

### 5.3 System Function Implementation

The client of the blockchain based ethnic cultural resource copyright protection system is a web application, and the server is currently running on a VMware virtual machine, serving as the Orderer and Peer nodes of the Hyperledger Fabric blockchain, and also deploying IPFS. The operating system is Ubuntu 16.04, and the Fabric version is V2.4.

As shown in Figure 2, the copyright transfer interface allows authenticated users to transfer their own copyright objects:

1) Transfer out: Users can transfer out copyrighted objects under their own name by entering the other party's name and system platform ID;

2) Confirmation of receipt: After someone transfers it out to oneself, there will be a prompt on their system indicating that there is copyright transferred in and confirmation is required. Click confirm;

3) Copyright certificate change: After confirmation, the system generates a new blockchain copyright certificate.

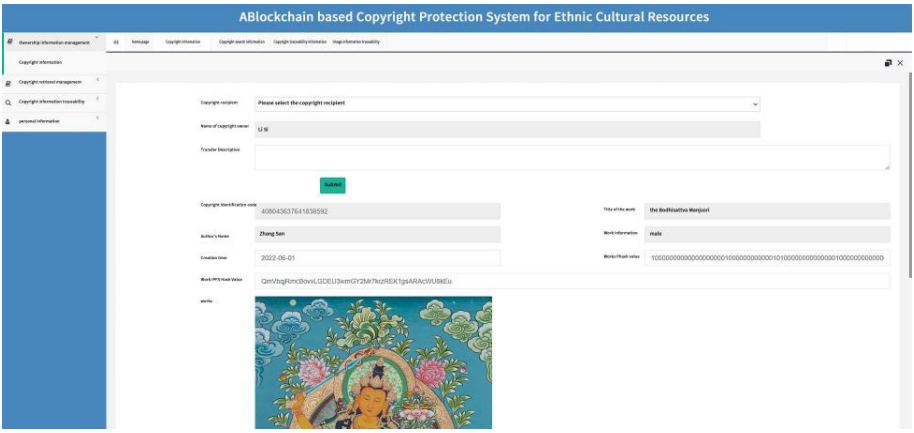


**Fig. 2.** assignment of copyright

## 6 SYSTEM TESTING AND EVALUATION

In order to verify the performance of the system, the testing environment used in this article is a Windows 10 operating system configured with CPU Intel (R) Core (TM) i7-8700 CPU @ 3.20GHz and 8GB of memory, installed with a VMware virtual machine and Ubuntu 16.04 system. The system has a total of five functional modules, among which the copyright registration module is the most core and basic function. This module is the most time-consuming and storage space consuming, as it involves the processing of image files using the Phash algorithm and the storage of image feature fingerprint data. Next, we will test the copyright registration module of the system.

This article systematically registers the copyright of 35 different ethnic and cultural works in sequence. Among these 35 works, 30 were successfully registered, with a success rate of 85%. The 5 works that failed copyright registration were numbered 9, 15, 19, 22, and 27, respectively. These 5 works all failed after image similarity comparison, so the accuracy is 86%.

This test successfully registered the copyright of 30 ethnic cultural works in the system of this article, and the registration time for each work is shown in Figure 3. In Figure 3, the slope of the total time spent on copyright registration is approximately 1.22, which means that for each work registered and confirmed by the system, the copyright registration time for subsequent works will increase by approximately 1.22 seconds. The slope of the time spent on similarity comparison in the system is about 1.22, which is almost the same as the slope of the total duration of copyright registration.

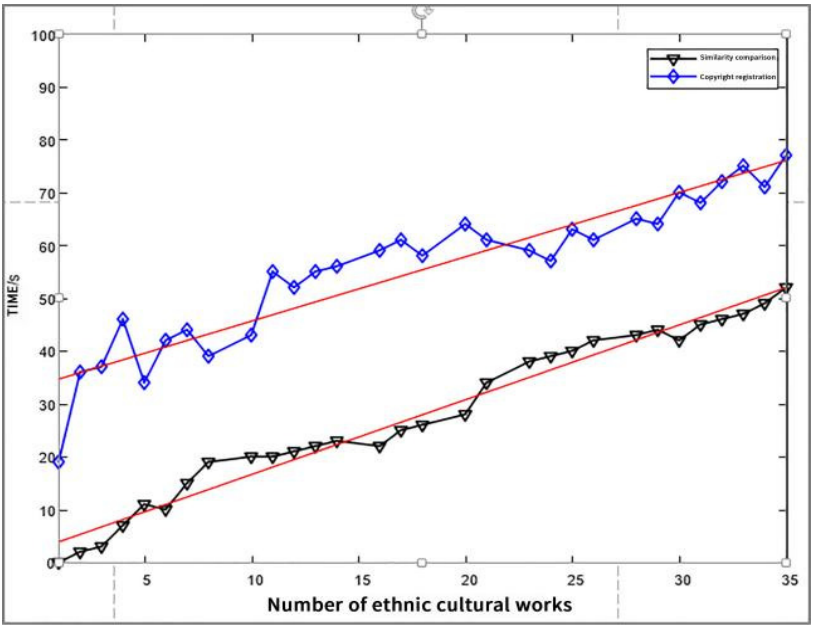


**Fig. 3.** Time spent in copyright registration

To verify the performance of the system, this article uses the transaction volume processed per second as the evaluation criterion for system throughput (TPS). Calculate the throughput of smart contracts related to different concurrent requests, set the concurrency to 50, 100, 200, 300, 400, 500, 600, 700, 800, 900, and 1000, and conduct 10 experiments in sequence to obtain the average value, as shown in Figure 4.

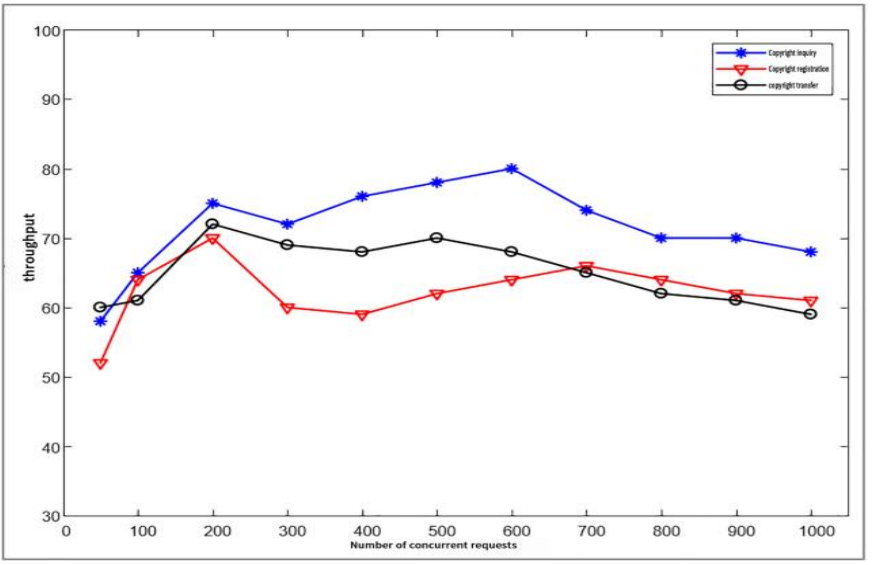


**Fig. 4.** Throughput of the same smart contract with different concurrent requests

1) The throughput of write operations is lower than that of read operations, meaning that write operations consume more time than read operations. The write operation finds the location of the data based on the index value. When new data is written to the current location, the old data needs to generate a historical version to achieve data traceability, while the read operation only needs to search for the location of the data based on the index value and return the data. Therefore, the write operation requires more time.

2) The throughput of the system increases first and then decreases with the increase of concurrent requests. When the number of concurrent requests reaches a certain value, the throughput of the system tends to stabilize because the number of connections in the blockchain network connection pool has reached the upper limit. However, it does not affect the transactions of each node, and each transaction is completed in the form of a queue.

3) The throughput of smart contracts for copyright registration is maintained at around 62, the throughput of smart contracts for copyright information query is maintained at around 71, and the throughput of smart contracts for copyright transfer is maintained at around 65.

This article uses a consortium chain to construct a copyright protection system for ethnic cultural resources, which includes copyright registration, copyright inquiry, copyright certification, and copyright transfer.

## 7 CONCLUSION

This article starts with three difficulties in digital copyright protection, and combines Qinghai's unique ethnic cultural resources to propose a decentralized ethnic cultural resource copyright protection system that uses Hyperledger Fabric blockchain and smart contracts to achieve copyright registration, certification, and transfer, and uses IPFS to store digital works copyright. The system supports real-time digital copyright registration, querying, and transmission of images, and can automatically determine whether the uploaded images are infringing. The non tampering properties of blockchain can record all processes of image copyright registration and transfer. Smart contracts in blockchain can automatically regulate the exercise and traceability of all copyrights, reduce the cost of rights confirmation, and improve transaction efficiency. It can be said that the blockchain based copyright protection system for ethnic cultural resources makes the registration, confirmation, and protection of copyright for ethnic cultural works faster, cheaper, and more convenient. This system is only aimed at copyright protection of image works in ethnic cultural resources. In the future, improvements will be made to include objects of copyright protection such as ethnic music and ethnic texts, improving the usability of the system and contributing to the copyright protection of ethnic cultural works.

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