

Research Article

Lei Su, Mengqi Fang*, and Gaoxiang He

Mathematical media art protection and paper-cut animation design under blockchain technology

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Abstract: At present, blockchain technology has been applied in different fields such as finance, Internet of Things, logistics, digital copyright, and public services, but it is less used in the field of paper-cut animation. Therefore, the use of blockchain to design a copyright protection model for paper-cut animation design based on blockchain is crucial to the progress of paper-cut animation design. This work combines various technologies such as blockchain technology, InterPlanetary File System (IPFS) technology, and Node.js technology for integrated design and construction. In the construction of the system model, the relevant characteristics of the blockchain technology show that the blockchain can provide a new and effective method for digital copyright protection; IPFS technology provides distributed and secure storage for massive amounts of oil and gas knowledge and achievement data; and the relevant development framework and technical characteristics of Node.js technology provide a reliable programming foundation for the realization of the system. Through the construction of the digital copyright protection system model based on the blockchain, the blockchain technology is used to realize the protection of the digital copyright of the knowledge achievement data of paper-cut animation. The results show that the model has high security and is more economical and practical than other existing models. In a word, the copyright protection model of paper-cut animation design based on blockchain can fully protect the rights and interests of creative talents of paper-cut animation, thereby promoting the progress of paper-cut animation industry.

Keywords: blockchain, copyright protection, paper-cut animation

1 Introduction

As an important support and engine in the process of human society, the integration of culture and technology is one of the long-standing topics in the research field. Especially with the breakthroughs and breakthroughs in the information network and high-tech fields in recent years, the interaction and fusion effect of culture and technology has been continuously enhanced [1]. As an important part of the world animation, Chinese animation is hailed as the “Chinese School” by the world animation industry [2]. Paper-cut animation and ink animation are known as the “Chinese school”, and they have an irreplaceable position in the long history of Chinese animation [3]. Because of its unique Chinese cultural temperament, paper-cut animation has high artistic value and social value. Since the new century, countries around the world have paid more and more

* **Corresponding author: Mengqi Fang**, Public Arts Department, Sichuan Fine Arts Institute, Chongqing, 401331, China, e-mail: fangmengqi@scfai.edu.cn

Lei Su: College of Fine Arts, Chongqing Normal University, Chongqing, 401331, China, e-mail: 20132071@cqnu.edu.cn

Gaoxiang He: Wealth Management College, Chongqing Finance and Economics College, Chongqing, 401331, China, e-mail: 309503875@qq.com

attention to the cultural and economic benefits brought by the animation industry. With the advent of digital media technology, the use of digital media technology to continuously “update” and “upgrade” national animation, making paper-cut animation a new development direction of national animation, is becoming a new application field of digital media technology and Development focus [4]. For the development of paper-cut animation, it is not only necessary to develop and inherit but also to use new technical means and methods to improve and improve, to give paper-cut animation new vitality, and to make paper-cut animation a new direction for the development of animation in China [5]. However, there are certain problems in animation creativity in the development of animation. The formation of these problems is caused by historical problems and different practical problems. Whether from a macro perspective or a micro perspective, animation creativity must be paid attention to at the height of awareness of all aspects of the entire industry chain [3]. Therefore, we must adopt systematic thinking and multi-dimensional inspection concepts to scientifically dismantle the various fetters entangled in animation creative issues. Taking animation creativity as the carrier, it will take advantage of the momentum to show the charm of Chinese animation and continue to carry forward five thousand years of Chinese culture.

To a certain extent and concept, blockchain technology can be understood as a decentralized and distributed shared database storage technology [6]. Blockchain technology is a specific chain data structure formed between each block according to the specified time sequence, in which the security of block data is guaranteed by the use of cryptographic methods. At the same time, as a kind of database, blockchain uses corresponding smart contracts and consensus mechanisms to generate and operate database data [7]. Blockchain originated from Bitcoin and has been valued by various industries for its technical characteristics such as decentralization, openness, and security [8]. At present, blockchain technology has been demonstrated by many scholars to have high application value in different fields such as finance, Internet of Things, logistics, digital copyright, and public services [9]. Compared with foreign countries, the research on blockchain technology started relatively late in China. However, the current investment and financing projects in the blockchain field are showing a trend of rapid growth. China's blockchain technology is rapidly maturing, and the future application potential is huge [10]. The use of blockchain technology to obtain the confirmation of animation creativity blockchain is an upgrading technology of the Internet, which will trigger the industrial ecological remodeling of many industries. At this time, the encounter between the animation industry and blockchain technology is not only conducive to the protection of animation creative intellectual property rights but also will have a deeper impact on the animation industry.

Therefore, based on the advantages of blockchain, this research innovatively proposes a copyright protection scheme for paper-cut animation design based on blockchain. In this scheme, first, the system model and system function in the basic idea of the scheme are expounded. Second, the metadata structure model and block data structure model in the scheme are explained. At the same time, the algorithm structure and functional functions of the core key technologies of this scheme are introduced, and finally, the proposed scheme is analyzed for security, performance test, and scheme comparison.

2 Design copyright protection scheme based on blockchain-based paper-cut animation

2.1 Blockchain

The blockchain technology has the following characteristics. (1) Decentralization and distributed storage: the blockchain technology is based on the principle of distributed peer-to-peer network protocols and mathematical methods and uses a decentralized network structure to realize the connection of each node in the blockchain. The nodes in the blockchain are fair and equal, and they can all participate in the blockchain system to maintain the blockchain's ledger. (2) Open, transparent, safe, and reliable: in the

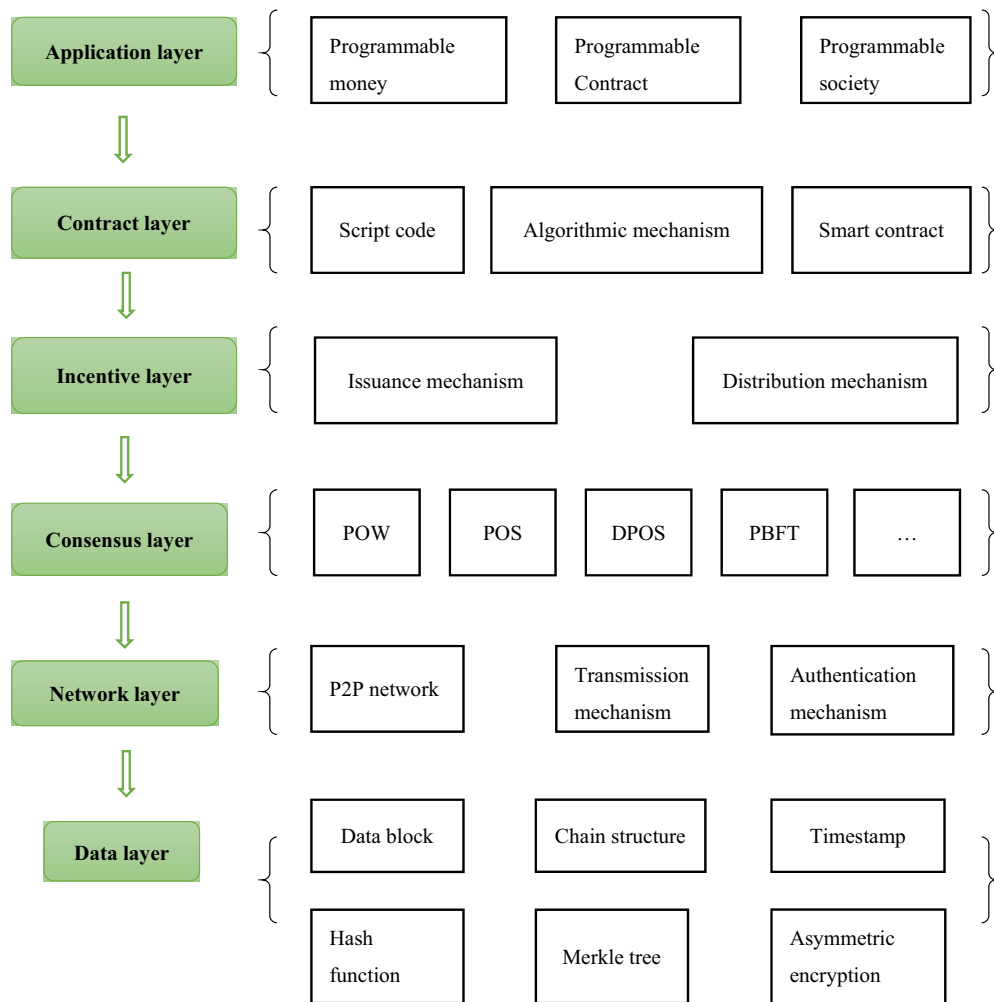


Figure 1: Architecture of blockchain.

blockchain, each transaction-related operation will be openly and transparently written into the blockchain's ledger, and each node in the blockchain can query each transaction information. At the same time, every transaction in the blockchain can be carried out autonomously, and the outside world cannot attack and interfere. (3) Immutable and confidential: in the blockchain, if malicious nodes tamper with data, a new hash value that does not match the original hash value will be formed, and this operation can be easily discovered by the blockchain [11,12]. The cryptographic method in blockchain ensures the security and reliability of all transaction data information to a certain extent. The many characteristics and practical applications of blockchain provide a method to solve the high risk, inefficiency, and insecure storage of data faced by previous centralization [13]. In the technical application process of blockchain, no matter which form of blockchain is adopted, they have similarities in the overall system architecture. The overall architecture is shown in Figure 1.

2.2 Block data structure

In blockchain, blocks are composed of block body and block header [14]. Its structure is shown in Figure 2. The entire block contains various attribute information, and the attribute information of the block hash value in those attribute information provides each block with a chain of block data that is connected back and forth

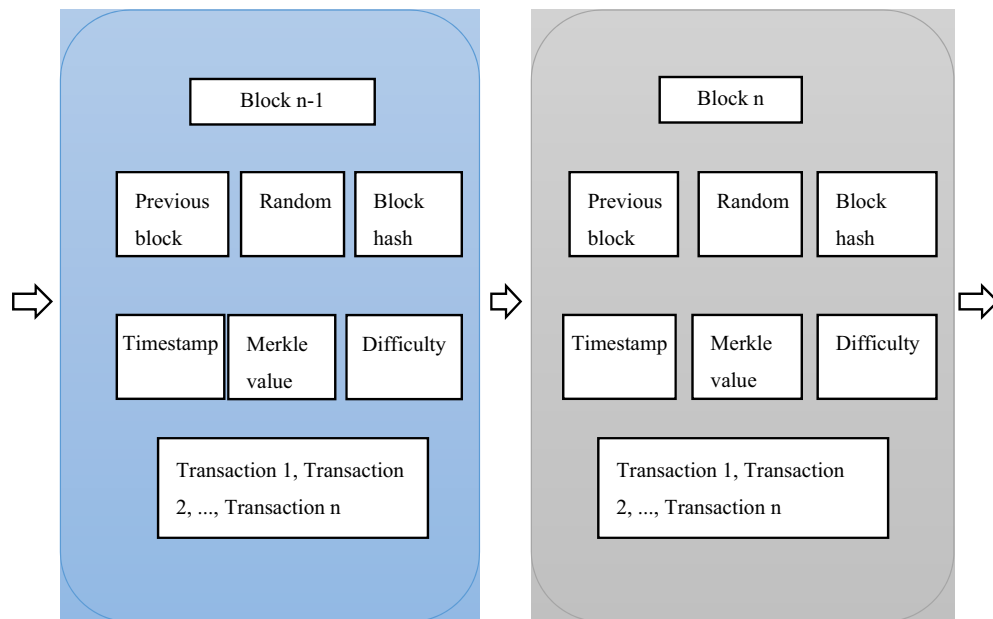


Figure 2: Blockchain structure.

and can be traced back. In the process of block generation, to avoid blockchain branching, blockchain will summarize the computing power and workload previously spent. This newly generated block is then added to the blockchain according to the aggregated information [15]. All transaction information in the block body is connected in the form of Merkle tree. At the bottom of the tree, each transaction generates a hash value after hashing and finally generates a hash root upwards in the form of a binary tree. It is assumed that if a transaction in the block changes, its hash value will also change. It is precisely because of this property that the blockchain is provided with an immutable feature [16].

2.3 Copyright protection scheme of paper-cut animation based on blockchain

To realize the effective security protection of digital copyright of oil and gas knowledge achievement data, a system model is constructed in this scheme. The system model as a whole combines the characteristics and advantages of various technologies such as blockchain technology, IPFS technology, and Node.js technology for integrated design and construction. In the construction of the system model, the relevant characteristics of blockchain technology show that blockchain can provide a new and effective way for digital copyright protection; IPFS technology provides distributed and secure storage for the massive and huge oil and gas knowledge achievement data [17]; and the relevant development framework and technical characteristics of Node.js technology provide a reliable programming foundation for the realization of the system [18]. Through the construction of the digital copyright protection system model based on blockchain, the protection of paper-cut animation design copyright is realized by using blockchain technology. In the system model, the chain structure of the blockchain can completely record the entire change process of the copyright information of the paper-cut animation, and the Merkle tree structure in the block ensures that the blockchain ledger data cannot be tampered with. Smart contracts formulate corresponding functional functions for the relevant business logic and behavior of the system and provide users with a series of application functions related to digital copyright protection [19]. The decentralization feature of blockchain technology ensures the distributed storage of knowledge achievement data copyright information. Through the relevant research on traditional digital copyright protection technology, combined with the characteristics of various aspects of the above blockchain technology. The system model of the relevant scheme is shown in Figure 3.

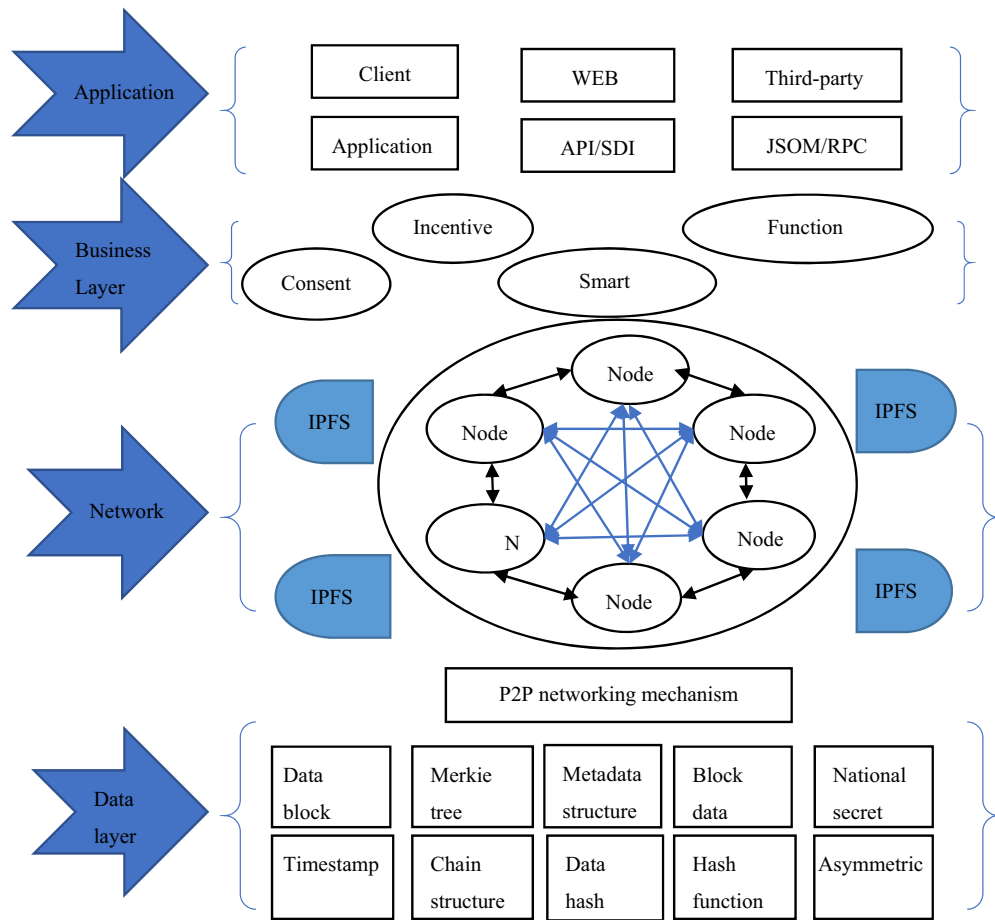


Figure 3: System model of design copyright protection scheme for blockchain-based paper-cut animation.

As can be seen from the system model diagram of the scheme, the system model of the copyright protection scheme based on paper-cut animation of blockchain is divided into four layers: data layer, network layer, business layer, and application layer. In the model of the whole system, each layer has its own functions and characteristics. At the same time, various core key technologies that can support the program to realize the main function modules are used throughout the design of each layer. The bottom layer of the digital copyright protection scheme system model is the data layer. The data layer is the most basic layer in the system model, including the designed oil and gas knowledge achievement metadata structure, block data structure, cryptography methods, the hash value of the oil and gas knowledge achievement data, the data attribute structure information related to the data block, timestamp, and blockchain structure in the blockchain. The design of the data layer provides a guarantee for the secure storage of paper-cut animation design copyright information in the blockchain. At the same time, the relevant technical features in the data layer also provide the most basic encryption design and distributed storage for paper-cut animation design copyright information. realization conditions. The network layer is an important part of the system model, providing support for the distributed characteristics of the system. In the network layer, it mainly includes the P2P networking mechanism and IPFS [20] between the nodes of the system. The P2P networking mechanism provides a point-to-point network connection between system network nodes and provides the possibility for distributed storage of copyright information for paper-cut animation design. At the same time, IPFS, as a point-to-point distributed file system, can be used to store a large amount of paper-cut animation design data. The business layer is an upper-layer design that integrates various technologies such as smart contracts, incentive mechanisms, and consensus mechanisms in the digital copyright protection system model. In the business layer, the design of the system functions is realized by using the smart contract technology in the blockchain. At the same time, the business

layer is based on the metadata structure and blockchain block data structure previously designed in the data layer, realizing the related functions such as digital copyright registration, digital copyright confirmation, digital copyright information query, and data sharing in the system model. The top layer of the system model is the application layer, which provides users with relevant applications for copyright protection and provides users with a visual system interface. interaction between. At the same time, the application layer provides users with application management and many interface functions. Users can use the interface to call related functions designed in the business layer. to realize the user's functional application requirements of the system, and the user can complete the improvement of the system application function in this layer.

2.4 System features of the scheme

In the process of system function realization and practical application, the system constructed by this solution mainly provides a series of application function services for the copyright protection of paper-cut animation design. The system can meet various requirements of users. The overall functional modules of the system can be divided into IPFS storage designed by paper-cut animation, digital copyright information encryption, digital copyright registration, digital copyright confirmation, and digital copyright information query and data sharing. The functional module structure of the solution system is shown in Figure 4. Among them, in the IPFS storage function module designed by paper-cut animation, users can use IPFS to store a large amount of paper-cut animation knowledge achievement data, which solves the problem that blocks in the blockchain cannot store a large amount of data. The digital copyright information encryption module realizes the encryption of the digital copyright information of the knowledge achievement data by using the national secret algorithm and achieves the privacy protection of the copyright information of the paper-cut animation knowledge achievement data. The digital copyright registration function module realizes the digital copyright registration of knowledge achievement data. The digital copyright confirmation function module realizes

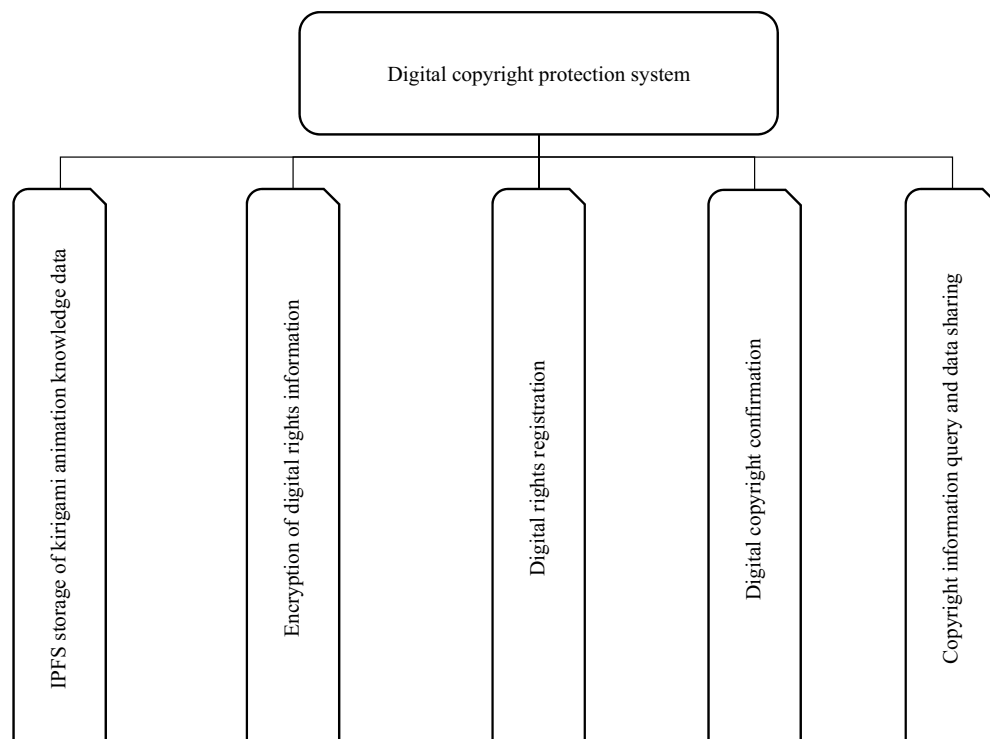


Figure 4: Functional module.

the functions of attribution verification and digital copyright confirmation of the copyright of the digital copyright information registered in the blockchain ledger. The digital copyright information query and data sharing function module realizes the digital copyright information query and data query and sharing of paper-cut animation knowledge achievements.

2.5 Metadata structure

The author information, data structure, data attributes, data hash value, and data address index of the paper-cut animation knowledge achievement data can fully display and represent the aspects of the paper-cut animation knowledge achievement data. Therefore, according to the relevant characteristics of the paper-cut animation knowledge achievement data and many attribute information of the data, a more comprehensive analysis and summary of the paper-cut animation knowledge achievement data in the paper-cut animation industry was carried out. The purpose is to carry out digital copyright protection and digital intelligent management of paper-cut animation knowledge achievement data in various oil fields and research institutions more conveniently and efficiently [21]. On the basis of analyzing and summarizing the above five dimensions of oil and gas knowledge achievement data, the construction of the metadata structure model of paper-cut animation knowledge achievement data is realized. The metadata structure model of paper-cut animation knowledge achievement data is shown in Figure 5. Among them, the attribute information of the metadata structure of the paper-cut animation knowledge achievement data can be represented as the following tuple: metadata structure = (ID, author information, data type, data attribute, knowledge achievement data hash value, address index).

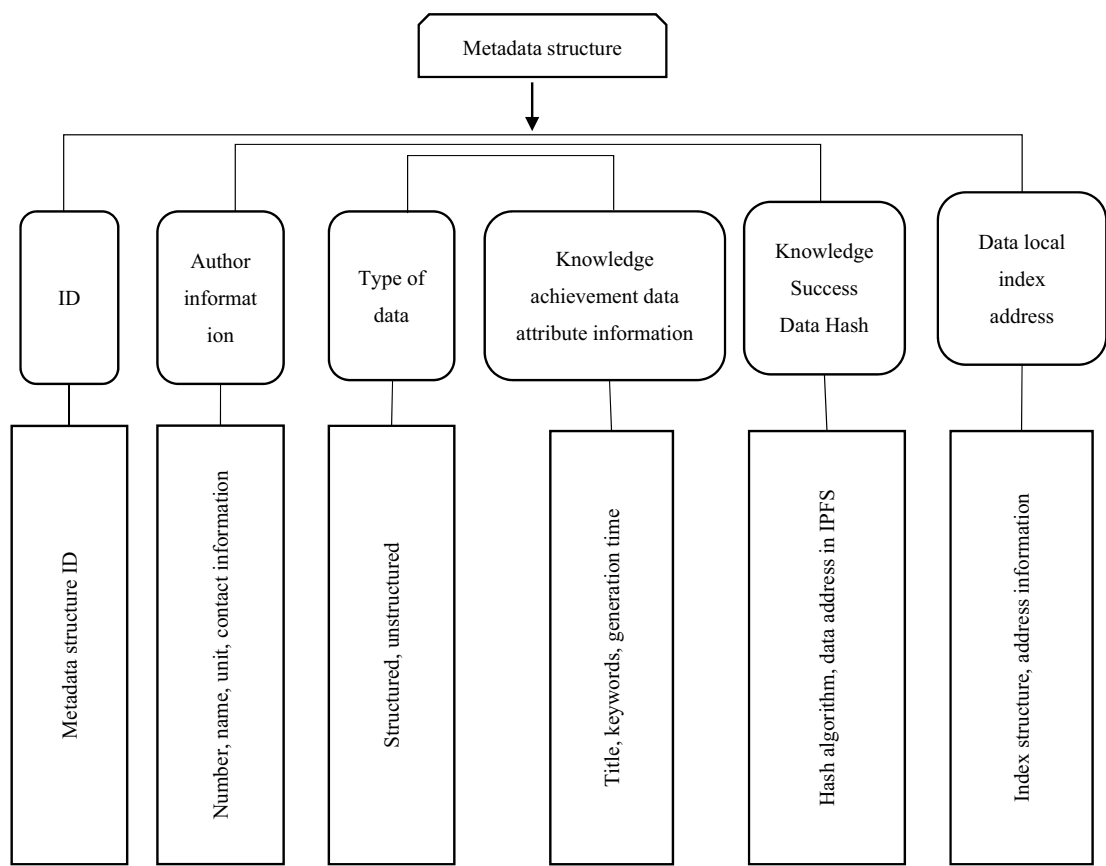


Figure 5: Metadata structure model.

2.6 Block data structure

In the chain structure of the Fabric Alliance blockchain, the data structure of its block is divided into three parts, namely block header, block data, and block metadata [22]. In these three parts, all digital copyright information in the paper-cut animation knowledge achievement data is included. The digital copyright information of the paper-cut animation knowledge achievement data is analyzed and summarized in the metadata structure model. Therefore, on the basis of the previously constructed metadata structure model of the paper-cut animation knowledge result data, the block data structure model in the digital copyright protection scheme of the paper-cut animation knowledge result data based on blockchain is constructed by combining with the relevant structural characteristics of the blocks in the alliance blockchain. The construction of the block data structure model will make the business needs of system users clearer and facilitate the development and implementation of the later system. In the process of building the block data structure model, the paper-cut animation knowledge achievement data digital copyright information and all aspects of user-related attributes are comprehensively considered. The block data structure model is shown in Figure 6.

As can be seen from Figure 6, in the block data structure model we constructed, each block is composed of block header, block data, and block metadata. The block header, block data, and block metadata of the block are respectively composed of the relevant attribute information of the user and the paper-cut animation knowledge achievement data held by the user. In general, the block header contains a series of attribute information of the block in the block data model as a whole, and the attribute information of the block hash

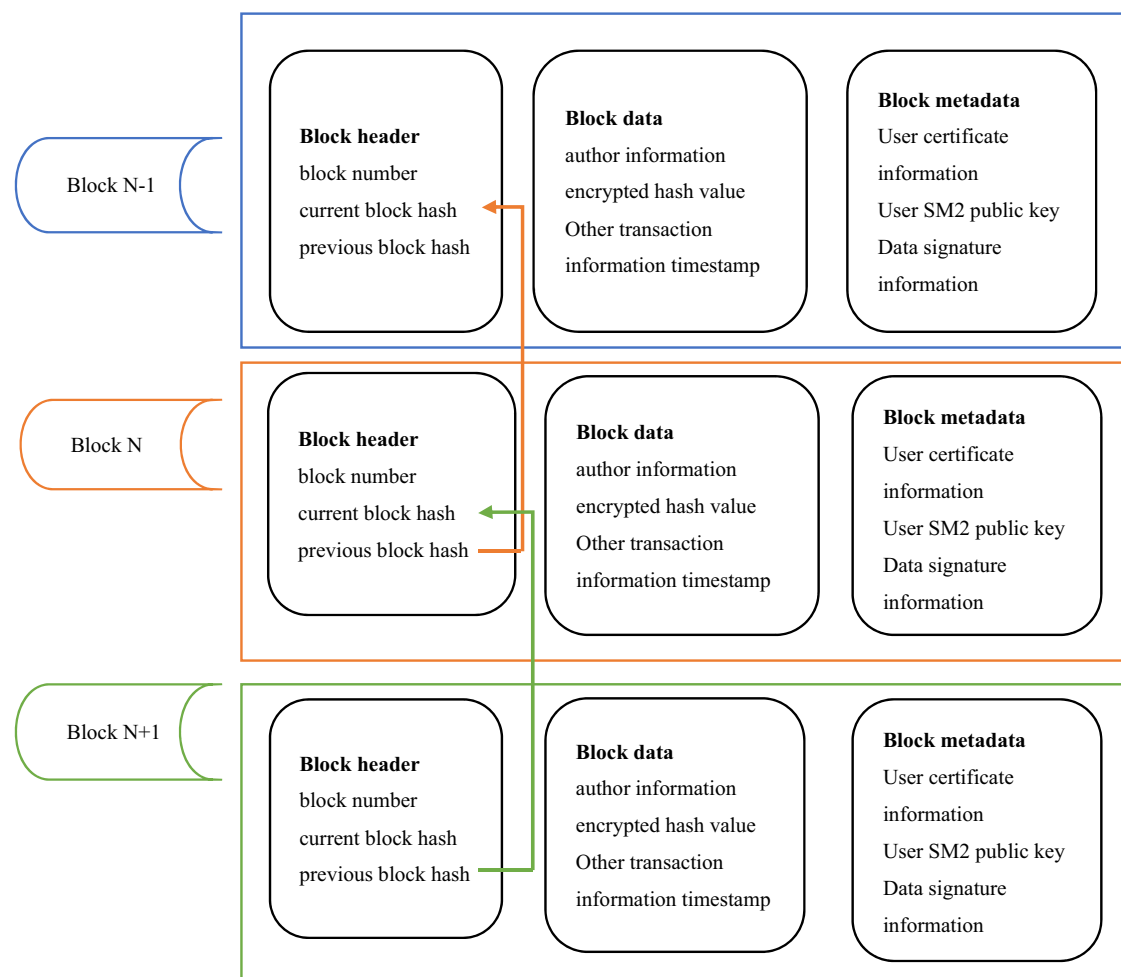


Figure 6: Block data structure model.

value in it plays a role in connecting the alliance blocks. The block data part in the block data model contains the relevant attribute information of the paper-cut animation knowledge achievement data, such as the data author's information and other transaction information. The attribute information is the core key information of oil and gas knowledge achievement data stored in the blockchain ledger and is an important embodiment of digital copyright information of digital copyright paper-cut animation knowledge achievement data. In the block metadata, the system user's certificate information, key information, digital signature, and other information are summarized and classified, and such specific attribute information is written into the block metadata. Through the design of block header, block data, and block metadata, the data structure model of the block in the scheme is more clarified. For this block data structure model, the digital copyright information of the paper-cut animation knowledge achievement data can be recorded more clearly and transparently on the blockchain ledger in the solution system.

3 Security analysis of the scheme

In the system proposed by this scheme, the copyright information of the paper-cut animation knowledge achievement data adopts a variety of cryptographic techniques in terms of storage, which has a good resistance and protection ability against illegal attacks on the network in the past. Since the entire system adopts the alliance blockchain in the development and implementation, the user nodes in the system can only enter the system after they have undergone various authentications and authorizations of the system. Through this measure, the joining of illegal users, malicious attacks, and wanton destruction are avoided, and the safe operation of the system is guaranteed. The system also has the following three advantages in other aspects of security. (1) The distributed data storage method is used to avoid the problem of single-node failure. Different from the previous centralized storage method, the paper-cut animation knowledge achievement data and digital copyright information in this system adopt a distributed storage method, which avoids the risk of being vulnerable to malicious attacks and paralyzed by the previous centralized database. (2) A variety of cryptographic methods are adopted to protect the privacy of digital copyright information. In this system, the national secret algorithm is used to encrypt the digital copyright information of the oil and gas knowledge achievement data, so that the data information exists in the form of cipher text in the system, which provides a guarantee for the privacy of the knowledge achievement data in the oil and gas industry. (3) The use of consensus mechanism ensures the safe storage of data. All digital copyright information in this system is written into the blockchain ledger. Therefore, for illegal attackers, they can only tamper with data information after controlling more than 50% of the computing power of the entire network. However, this is very difficult for attackers.

4 Performance analysis and comparison of scheme

In this scheme, when the user is performing the operation of digital copyright registration, the process of digital copyright information forming a transaction information and recording it in the ledger of the blockchain to complete the digital copyright registration takes about 2 ms on average. Compared with traditional digital copyright registration, this shortens the time required for copyright registration and improves efficiency. In the process of using the SM2 algorithm to confirm the right of digital copyright, the SM2 algorithm improves the verification efficiency of digital copyright information. Compared with traditional or other RSA algorithms, the 256-bit SM2 algorithm is superior to the 2048-bit RSA algorithm in terms of security and is about ten times faster than the RSA algorithm in terms of digital signature speed. In addition, the SM2 algorithm saves more key space. In this scheme, when the number of users is 10, the system performs 100, 200, 300, and 500 digital copyright information query operations, and can process 450 requests per second on average. It can be seen that this scheme still has advantages in terms of performance. In terms of scheme comparison, the

Table 1: The performance comparison between the model in this work and other models

Type	Ref. [23]	Ref. [24]	Ref. [25]	Ref. [26]	Ref. [27]	Ref. [28]	Scheme in this work
Strong maneuverability	/	/	/	○	○	/	○
Perfect function	/	/	○	/	/	○	○
Good expandability	○	○	/	○	○	/	○
Strong privacy protection	○	/	○	/	/	○	○
Low cost	/	/	/	/	/	/	○
High throughput	/	○	○	/	/	○	○

Note: “○” indicates “yes” and “/” indicates “no”.

comparison between this system scheme and other schemes using blockchain technology to realize digital copyright protection system is shown in Table 1. The literature [23] uses blockchain technology to design and implement digital copyright authorization, storage, transfer, registration, and verification functions for users, providing effective protection for digital copyright information. However, in the scheme of this study, although the document scheme satisfies the user's registration of digital copyright, storage of digital copyright information, and related verification in the process of digital copyright protection. In addition, it realizes the authorization of digital copyright between two users. and transfer and a series of related applications. However, to a certain extent, the system of this solution is not easy to deploy as a whole, the system is not easy to expand, and the throughput rate of the system in the application process is low, and the external storage cost of data is high. Ref. [24] implements a digital copyright protection system by using digital fingerprints, IPFS, block hain, and other technologies, which realizes the storage of copyright information and effectively protects digital copyright information. In the implementation of the system scheme, the realized system application functions are relatively simple, and there are still many links in the scheme that need to be improved, and the system scheme can only meet the operation and application between single-target users. It is because of this that the system solution has a high throughput rate. At the same time, the privacy protection of digital copyright information is also realized in this system scheme, and this scheme saves cost in data storage. Ref. [25] proposes a digital copyright management system based on blockchain, which realizes the control of content, and can trace digital copyright information to ensure the safe storage of digital content metadata and achievement data. In this system scheme, the system functions are complete and can meet the various requirements of users, but the scheme system is not easy to deploy and function expansion, and the data storage cost is high. However, the system of this scheme has a high throughput rate in the testing process and can realize the privacy protection of digital copyright information. Ref. [26] proposes a management scheme for digital copyright by using blockchain. During the management process, copyright-related information is stored in the blockchain, and functions such as transactions are designed for users through smart contracts. In this scheme, the author uses the blockchain method of EOS to construct the system platform, and the application functions of the system still have areas for further improvement in this scheme. Therefore, this scheme is relatively easy to expand and deploy to a certain extent, but this scheme does not protect the privacy of data information and does not have a high throughput rate. Ref. [27] proposes a digital copyright management scheme of blockchain that can efficiently manage the production, transaction, behavior, and copyright of media data in the network. The function of the scheme system is relatively single, which cannot meet the needs of users, but it has a good performance in the scalability and deployment of the scheme system. However, the scheme system has defects in the privacy protection of digital copyright information, the storage cost of copyright information is high, and the system does not have a high throughput rate. Ref. [28] proposes a digital copyright protection and management system based on blockchain and can realize fine-grained usage control, which can manage users' digital copyright information more purposefully, safely, and conveniently. The scheme system can meet the user's requirements for digital copyright protection and management in all aspects, with complete functions, and has a high throughput rate in the performance test of the system. It can realize the privacy protection of digital copyright information in the process of digital copyright protection and management. However, the data storage cost of the digital copyright information of this system is high, and there are some deficiencies in the overall deployment and function expansion of the system.

5 Discussion

Technological progress has led to the dilemma of the ownership of animation creative intellectual property. Looking back at the history of the development of the world animation industry in the past 100 years, the evolution of animation technology has triggered a series of changes in the business models of animation companies such as animation content, animation production, and animation dissemination. For animation creativity, it shows the following four characteristics. ① From the perspective of the creative subject, it has gone through the process from single-person creation to multi-person and collaborative creation. ② From the point of view of the object of creation, it has experienced changes in the subject matter, characters, plot, duration, and other content elements of Dongluo's works. ③ From the perspective of the creative process, it includes both the complete work created by a single person and the combination of fragments created by multiple people. ④ From the point of view of the communication process, it includes both the one-time meeting with the audience in traditional broadcast channels (such as movie theaters and TV systems), and the multiple link viewing under network conditions [29]. The above-mentioned changes are intertwined, especially in the context of the "space-time compression" of China's animation industry, the attribution of animation creativity has become extremely complicated. This provides an opportunity for those who deliberately pirate and infringes and makes it extremely difficult to protect the rights and interests of the owners of animation ideas. The blockchain technology protects the ownership of animation creative intellectual property rights. It can also be said that the blockchain technology effectively solves the problem of the confirmation of the intellectual property rights of animation creativity. Blockchain is a distributed storage database, and its essence is that all nodes follow the same protocol. The protocol stipulates that all nodes obey a consensus algorithm, relying on this algorithm to keep all node data consistent [30]. Therefore, any node can become a phased center with the characteristics of "decentralization." Based on this, each node in the system has a complete copy of the database, and the modification of the database by a single or even multiple nodes cannot affect the databases of other nodes, and the data will not be tampered with. In this sense, blockchain technology can save the most original animation creative data records, and can completely record all the changes of animation creators from the initial inspiration to the final animation work. Through the "time stamp" chain and continuous digital signature based on cryptographic technology, it provides proof of existence and identity for any specific point in time, thus solving the ownership of animation copyright [31]. Infiltrate blockchain technology into all aspects of animation creative radiation. The emergence of blockchain technology can bring blessing to the copyright of animation creativity. In this work, the characteristics and advantages of various technologies such as blockchain technology, IPFS technology and Node.js technology are combined to carry out integrated design and construction. In the construction of the system model, the relevant characteristics of blockchain technology show that blockchain can provide a new and effective method for digital copyright protection; IPFS technology provides distributed and secure storage for massive amounts of oil and gas knowledge and achievement data; and the relevant development framework and technical characteristics of Node.js technology provide a reliable programming foundation for the realization of the system. Through the construction of the digital copyright protection system model based on blockchain, the protection of digital copyright of paper-cut animation knowledge achievement data is realized by using blockchain technology, and the security and economy of the model have been certified.

6 Conclusion

The emergence of blockchain technology can not only protect the interests of the owners of paper-cut animation creative property rights but also improve the transaction efficiency of paper-cut animation products. Therefore, on the basis of fully protecting the rights and interests of paper-cut animation creative talents, the content quality of paper-cut animation creativity can be more effectively improved.

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