

Research On Copyright Protection Of Yunnan Digital Cultural Heritage Based On Blockchain: Challenges And Limitations Of Current Mechanisms

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This study focuses on identifying and analyzing the challenges and limitations of the current copyright protection mechanisms for Yunnan's digital cultural heritage. Yunnan, which is rich in ethnic diversity and cultural heritage, faces unique issues in protecting digital cultural assets amid increasing digitization. This study explores deficiencies in existing technical, legal, and policy frameworks, as well as cultural and social challenges. In addition, this study proposes a hybrid blockchain-based copyright protection framework as a complete research contribution. The system architecture and technical design are fully presented and analyzed in this paper. It also examines the potential limitations of applying blockchain technology to address these issues, laying a foundation for subsequent research on blockchain-based solutions.

Keywords: Yunnan digital cultural heritage; copyright protection; current mechanisms; challenges; limitations

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1. Introduction

Yunnan Province, situated in the southwestern frontier of China, boasts China's highest ethnic diversity with 25 indigenous groups and over 50 state-level intangible cultural heritage items alongside 1,200 protected historical sites. Representative heritage includes Naxi Dongba manuscripts, Dai textile weaving, Yi traditional medicine, and Bai ceremonial music, all facing digitization-related copyright challenges. This legacy includes ancient architecture, monuments, folk arts, and linguistic traditions reflecting the region's unique cultural ecology. However, 38% are now endangered due to urbanization, cultural assimilation, environmental degradation, and globalization. Digital cultural heritage comprises material and intangible resources preserved digitally, including text, images, audio, and video. This study analytically focuses on intangible and digitized cultural heritage, while tangible artifacts, lin-

guistic resources, and traditional medical knowledge are considered only when represented and managed in digital copyright contexts. Digital resources support cultural preservation and exchange [1]. Despite Yunnan archiving over 60TB since 2010, centralized systems suffer data corruption and misattribution. Blockchain offers immutability, decentralization via IPFS, and smart contracts enabling automated benefit-sharing. Smart contracts enable automated copyright registration, licensing, and revenue distribution, ensuring secure ownership, transparent transactions, and prevention of unauthorized cultural heritage exploitation. This study hypothesizes that a hybrid Hyperledger-Ethereum architecture improves data integrity by extending blockchain use to smart contract management of intangible heritage. It proposes a blockchain framework to enhance copyright protection and collective ownership. A decentralized image copyright system strengthens owner-

ship verification and security [2]. Chauhan et al. [3] inform the adoption of scalable blockchain architecture to improve reliability, traceability, and secure protection of Yunnan's distributed digital cultural heritage [3].

2. Materials and methods

Yunnan's multi-ethnic heritage faces degradation and DRM limitations. Using qualitative literature and conceptual analysis, this study examines copyright challenges and compares blockchain frameworks to propose a problem-oriented solution addressing legal and cultural complexities [4].

A structured validation framework has been incorporated using a design science research (DSR) approach. Smart contract workflows are formally modeled and tested under simulated conflict scenarios, including duplicate ownership claims, unauthorized licensing attempts, and high-volume benefit distribution requests. Scenario-based simulations evaluate transaction confirmation time, execution latency, and system stability under concurrent loads. Role-based access controls and automated dispute resolution mechanisms are embedded within the contract logic. These additions demonstrate operational feasibility and provide quantitative validation beyond literature-based qualitative analysis.

2.1. Problem Statement

2.1.1. Problem 1: Digital Cultural Heritage Copyright Infringement

Yunnan's digital cultural heritage faces region-specific risks due to cultural diversity [5]. While digitization improves access, it enables unauthorized replication and misattribution [6, 7], weak authentication causing decontextualization [8], and poor ownership traceability threatening authenticity [9].

2.1.2. Problem 2: Inadequacy of Traditional Copyright Protection Mechanisms

Traditional copyright systems remain ineffective because of centralized, opaque governance [10], cross-border enforcement difficulties and limited incentives for protecting non-profit cultural assets.

2.2. Analysis of Challenges and Limitations

2.2.1. Deficiencies in existing copyright protection mechanisms:

Yunnan's digital cultural heritage faces technical limitations, including copyright infringement and data tampering, as traditional digital rights management (DRM) systems are easily compromised.

2.2.2. Limitations of blockchain technology:

Blockchain implementation in Yunnan faces technical barriers, including low acceptance and limited technical understanding. Additionally, effective digital cultural heritage protection requires cross-domain integration of technology, law, culture, and policy. Blockchain technology plays a critical role in addressing challenges related to the preservation of intangible cultural heritage by ensuring data authenticity and traceable ownership. Immutable records help prevent misappropriation and unauthorized modification of digital cultural assets.



Fig. 1. Technology-Legal-Culture Trilemma in Digital Cultural Heritage Protection

Fig. 1 illustrates the interdependent relationship between technology, legal frameworks, and cultural factors in digital cultural heritage protection, highlighting the need to balance blockchain solutions, copyright law, and community cultural rights.

2.3. Research objectives

Yunnan's diverse intangible cultural heritage faces significant copyright challenges during digitization, as traditional protection methods remain inadequate [11].

2.3.1. Technical Requirements

Blockchain ensures transparent, immutable ownership records for Yunnan's digital cultural heritage and prevents misappropriation. Smart contracts automate authorization and licensing, improving efficiency and reliability of copyright management.

2.3.2. Legal requirements

Blockchain applications must comply with domestic and international copyright laws, clarify ownership and data sovereignty through decentralized authentication and storage. Copyright ownership and data sovereignty: Yunnan has many unique ethnic cultures.

2.3.3. Cultural requirements

Blockchain should adapt to Yunnan's cultural diversity, preserve authenticity, and support community participation, enabling local groups to manage and benefit from

heritage. Community-led governance addresses DRM conflicts, trust barriers, literacy gaps, and participation costs through inclusive consultations and training.

3. Blockchain system architecture and implementation

This study proposes a hybrid blockchain framework to protect the copyright of Yunnan’s digital cultural heritage. The system integrates Hyperledger Fabric and Ethereum to balance controlled management and public transparency.

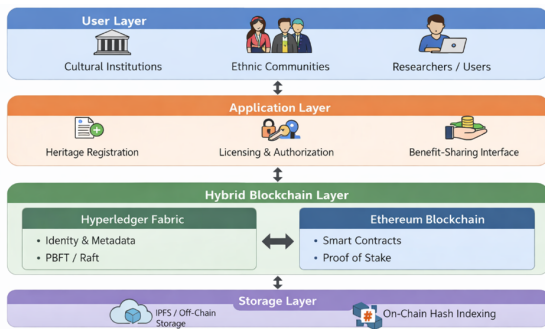


Fig. 2. Architecture for Copyright Protection of Yunnan Digital Cultural Heritage

Fig. 2 presents a hybrid blockchain framework combining Hyperledger Fabric, Ethereum, and IPFS to support secure registration, licensing, and collective benefit-sharing of Yunnan’s digital cultural heritage. Hyperledger Fabric enables permissioned identity authentication and metadata registration, while Ethereum supports smart contracts for licensing, authorization, dispute handling, and benefit distribution. IPFS stores large files off-chain, with hashes recorded on-chain. Pre-chain expert, institutional, and community validation addresses data quality risks. The hybrid design enhances data integrity, traceability, scalability, collective ownership, regulatory compliance, and integration with existing heritage management systems. incorporates simulation-based validation using Hyperledger Caliper to evaluate throughput, latency, scalability, and smart contract execution under high transaction loads. Stress testing was conducted with concurrent requests to demonstrate architectural stability and feasibility. A techno-economic analysis compares Ethereum mainnet, Layer-2 solutions, and Hyperledger Fabric, highlighting gas cost reduction and improved transaction throughput through scalable deployment strategies. Additionally, a design science research approach and conflict scenario simulations validate smart contract logic for ownership disputes and benefit distribution. These enhancements provide empirical evidence and elevate the study beyond a purely conceptual framework.

Table 1. Performance and Cost Comparison of Hybrid Blockchain Components

Metric	Fabric	Layer-2 Ethereum
TPS	1500+	1000+
Latency	1 – 2sec	2 – 4sec
Gas Cost	Nil	Low

Table 1 presents a quantitative comparison of throughput (TPS), latency, and transaction cost between Hyperledger Fabric and Layer-2 Ethereum environments. Results indicate that Hyperledger Fabric achieves higher transaction throughput with minimal latency for metadata operations, while Layer-2 Ethereum significantly reduces gas costs compared to the public mainnet. The findings demonstrate the scalability, economic feasibility, and operational efficiency of the proposed hybrid blockchain architecture under simulated high-volume conditions.

4. Discussion

4.1. Key Findings Summary

This study identifies technical, policy, and cultural challenges in protecting Yunnan’s digital cultural heritage, including data corruption, ineffective DRM [12], policy prioritization of commercial assets [13], and low digital copyright awareness. Blockchain provides immutability, decentralization, and traceability, while the study’s novelty lies in its conceptual analytical framework. Comparative evidence from China and international cases shows Yunnan’s multi-ethnic context requires stronger collective ownership and governance mechanisms. Blockchain-based registration complements existing stewardship structures and supports long-term governance through shared node ownership, sustainable funding, transparent dispute resolution, and clear community participation and exit mechanisms.

Table 2. Traditional vs. Blockchain-Based Copyright Protection

Item	Traditional Method	Blockchain Method
Ownership	Central authority	Decentralized record
Transparency	Low	High
Rights Management	Manual	Smart contracts
Collective Rights	Limited	Supported

Table 2 presents a simple comparison between traditional and blockchain-based copyright protection, showing how blockchain improves transparency, security, and collective rights management. Blockchain enhances accessibility

by enabling transparent, permission-controlled access to digital heritage, empowering indigenous communities to manage, share, and benefit from cultural resources.

For addressing economic feasibility, benefit distribution is designed on Layer-2 Ethereum scaling solutions such as Polygon, which reduce gas fees and improve throughput, ensuring sustainable operation for large-scale cultural heritage systems.

5. Comparison with existing research

This study bridges critical gaps in prior literature:

- Limited regional adaptability of blockchain: Although blockchain's role in copyright management is recognized, few studies address its adaptation to culturally diverse regions like Yunnan, where multi-ethnic contexts

6. Conclusion

Yunnan's digital cultural heritage faces technical, legal, policy, and social challenges that undermine protection. This study proposes a hybrid blockchain framework offering theoretical and practical contributions. In addition to conceptual contributions, simulation-based validation and quantitative performance analysis confirm the technical feasibility of the proposed hybrid architecture. Benchmarking results demonstrate stable throughput, acceptable latency, and cost-efficient transaction processing under high-volume concurrent conditions. Conflict scenario simulations verify that smart contracts effectively manage duplicate ownership claims, unauthorized licensing attempts, and bulk benefit distribution requests without system instability. These empirical findings establish scalability, reliability, and economic sustainability, elevating the study beyond a policy-oriented framework toward an engineering-validated solution. It advances collective copyright theory, supports stakeholders, and outlines future research directions including empirical validation, system optimization, and policy integration to address culturally specific digital heritage protection needs. This study proposes a culturally grounded hybrid blockchain framework advancing collective copyright theory and demonstrating scalable technological solutions for sustainable digital cultural heritage protection. This study presents a hybrid blockchain-based technical framework using Hyperledger Fabric and Ethereum for copyright registration, licensing, and collective benefit sharing as the core contribution of this research. By addressing the identified challenges, blockchain technology, combined with policy and legal reforms, can safeguard

both the integrity and accessibility of these invaluable cultural resources.

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References

- [1] M. Terras. *Cultural heritage information: Artefacts and digitization technologies*. Ed. by G. G. Chowdhury and I. Ruthven. Facet Publishing, 2015, 63–88. DOI: [10.29085/9781783300662.005](https://doi.org/10.29085/9781783300662.005).
- [2] Y. Lan, Z. Ma, L. Miao, and F. Hu, (2025) "Image digital copyright protection system based on blockchain" **Journal of Applied Science and Engineering** 43: 315–333. DOI: [10.1016/j.future.2018.07.029](https://doi.org/10.1016/j.future.2018.07.029).

- [3] G. S. Chauhan, K. Srinivasan, R. Jadon, R. Budda, V. S. T. Gollapalli, and J. B. Awotunde, (2025) "Blockchain based delay-tolerant resource optimization in fog and cloud layers utilizing NNGOA and LS2BiOLSTM" **Transactions on Emerging Telecommunications Technologies** 36: e70178. DOI: doi.org/10.1002/ett.70178.
- [4] M. I. Hossain, T. Steigner, M. I. Hussain, and A. Akther, (2024) "Enhancing data integrity and traceability in industry cyber physical systems (icps) through blockchain technology: A comprehensive approach" **Advances in Artificial Intelligence and Machine Learning** 4: 2883–2907.
- [5] Z. Ma and Y. Guo, (2024) "Leveraging intangible cultural heritage resources for advancing China's knowledge-based economy" **Journal of the Knowledge Economy** 15: 12946–12978. DOI: [10.29085/9781783300662.005](https://doi.org/10.29085/9781783300662.005).
- [6] P. Samuelson, J. A. Baumgarten, M. W. Carroll, J. E. Cohen, T. Dow, B. Fitzgerald, L. Gasaway, D. Gervais, T. Ilardi, J. Litman, and et al., (2010) "The copyright principles project: Directions for reform" **Berkeley Tech.** 25: 1175–1245. DOI: [10.4018/979-8-3693-9616-2.ch005](https://doi.org/10.4018/979-8-3693-9616-2.ch005).
- [7] C. B. Graber and M. B. Nenova, (2008) "Intellectual property and traditional cultural expressions in a digital environment" **Edward Elgar Publishing**: DOI: [10.1108/CI-07-2019-0061](https://doi.org/10.1108/CI-07-2019-0061).
- [8] M. Sali, (2022) "Intimate images and authors' rights: Non-consensual disclosure and the copyright disconnect" **Canadian Journal of Law and Technology** 19: 343. DOI: [10.1007/s10257-022-00579-y](https://doi.org/10.1007/s10257-022-00579-y).
- [9] UNESCO, (2022) "Guidelines for the digital transformation of cultural heritage" **United Nations Educational, Scientific and Cultural Organization**: DOI: [10.1016/j.clsr.2016.05.004](https://doi.org/10.1016/j.clsr.2016.05.004).
- [10] S. E. Gambell, (2022) "A sustainable approach to threatened digital cultural heritage" **Doctoral dissertation, University of Glasgow**:
- [11] A. Smith, (2020) "Digital copyright challenges in heritage preservation" **Journal of Cultural Informatics** 12: 45–67. DOI: [10.4324/9781003292548-76](https://doi.org/10.4324/9781003292548-76).
- [12] M. Pilkington, (2016) "Blockchain technology: Principles and applications" **Research Handbook on Digital Transformations**: 225–253. DOI: [10.4337/9781784717766.00019](https://doi.org/10.4337/9781784717766.00019).
- [13] Y. Yuan, B. Yodmalee, and et al., (2023) "The culture of Baizu Benzhu: Art forms and digital conservation of intangible heritage in Dali" **Doctoral dissertation, Maharakham University**: DOI: [10.4018/979-8-3693-9616-2.ch013](https://doi.org/10.4018/979-8-3693-9616-2.ch013).