ChinaRxiv

AI translation · View original & related papers at
chinarxiv.org/items/chinaxiv-202401.00353

Research on the Integration Model of Blockchain Technology and Open Peer Review

Authors: Wang Shaopeng, Qin Xue, Yang Na, Li Xue, Li Xue

Date: 2024-01-29T00:00:00+00:00

Abstract

Objective To construct an integration model of blockchain technology and open peer review, address the pain point problems currently existing in the open peer review model, and explore a high-quality academic review system for scientific journals. Methods By analyzing the necessity and challenges of the open peer review model and combining the characteristics of blockchain technology and IPFS technology, we constructed an integration model of blockchain technology and open peer review. Results By applying blockchain and IPFS technology to the open peer review model, issues such as identity authentication and participation scope of all parties involved in the review were effectively resolved through smart contracts and channel functions. Additionally, we proposed "intangible" and "tangible" incentive mechanisms that enhance the enthusiasm of all parties while establishing effective constraints. Conclusion Blockchain technology can effectively address some of the existing challenges in open peer review, and while improving fairness and transparency, it can effectively ensure the security and privacy of information for all parties. However, the true implementation and deployment of the integration model remains a formidable task, requiring further in-depth research at the policy, infrastructure, and technical levels.

Full Text

Research on the Integration Model of Blockchain Technology and Open Peer Review

WANG Shaopeng[1]), QIN Xue[1]), YANG Na[1]), LI Xue[2])
[1]) Editorial Office of *Marine Science Bulletin*, 93 Liuwei Road, Hedong District, Tianjin 300171, China
[2]) Editorial Office of *Ocean-Land-Atmosphere Research*, 4 Haiqin, Sun Yat-sen University (Zhuhai Campus), Xiangzhou District, Zhuhai 519082, China

Abstract:
[Purpose] This study constructs an integration model of blockchain and IPFS technology with open peer review to address existing pain points in open peer review models and explore a high-quality academic review system for scientific journals. [Method] By analyzing the necessity and challenges of open peer review and leveraging the characteristics of blockchain and IPFS technology, we constructed a fusion model that integrates these technologies with open peer review. [Findings] The application of blockchain and IPFS to open peer review effectively resolves issues related to identity authentication and participation scope for all stakeholders through smart contracts and channel functionality. We propose both "intangible" and "tangible" incentive mechanisms that enhance participation while creating effective constraints. [Conclusion] Blockchain technology can effectively address certain challenges in current open peer review systems, improving fairness and transparency while safeguarding the security and privacy of all parties' information. However, practical implementation of this integration model remains a formidable task requiring further in-depth research at the policy, infrastructure, and technical levels.

Keywords: Open peer review; Blockchain; IPFS; Authentication+Authorization

Author Contributions:
WANG Shaopeng: Conceptualization, framework design, writing and reviewing; LI Xue: Framework modification, paper revision; QIN Xue: Material collection, paper revision, figure preparation; YANG Na: Assisted with secondary paper revision.

Open Science aims to make science more collaborative, transparent, and reproducible [1]. As a crucial platform for academic communication and dissemination, scientific journals are directly impacted by open science and must actively respond to its demands. Peer review serves as a critical quality control mechanism for academic journals, yet the current mainstream model is heavily influenced by subjective human factors, with limited checks on the power of reviewers and editors. Its scientific validity and objectivity have long faced controversy and skepticism, with surveys indicating that approximately half of authors believe the review process suffers from opacity and bias [2]. Consequently, traditional peer review models can no longer meet the requirements of open science, giving rise to the concept of Open Peer Review (OPR).

Open peer review, a term proposed relative to traditional peer review based on open science principles, offers several key advantages. First, it enhances review fairness. In traditional peer review, significant information and psychological power asymmetries exist between authors and reviewers, who must communicate through editorial offices, with review processes and reports remaining confidential [4]. Open peer review enables direct communication between authors and reviewers while making the review process and reports publicly accessible, thereby significantly improving transparency and fairness. Second, it curbs aca-

demic misconduct. The closed nature of traditional peer review provides no effective means to detect subtle forms of misconduct such as idea plagiarism or data/image manipulation [5]. By making papers publicly reviewable and subject to community oversight, open peer review both protects authors' academic priority and effectively deters academic misconduct. Third, it improves timeliness. Scientific innovation and cutting-edge ideas are highly time-sensitive. Under traditional peer review, papers remain unknown to the outside world until publication, causing delays in disseminating scientific viewpoints. The public nature of open peer review effectively preserves the timeliness of research.

Despite these theoretical advantages, open peer review faces numerous practical controversies and challenges, including personal privacy protection, public oversight management, and participation incentives. To explore a well-established and technologically mature open peer review model, scholars have proposed applying blockchain technology to the process. International researchers such as Ámbar et al. [6] have built a blockchain-based open peer review system using emerging technologies like blockchain and IPFS, employing the decentralized science (DeSci) concept to create a novel decentralized system for managing open peer review. Choi et al. [7] developed an open peer review system based on private blockchain Hyperledger Fabric, utilizing smart contracts to execute peer review workflows and establishing an evaluation model for reviewers. Mackey et al. [8] proposed constructing a blockchain-based decentralized autonomous organization to ensure peer review quality through decentralized game mechanisms. Domestic research remains in its infancy, with He Ying et al. [9] analyzing the internal logic of applying blockchain technology to open peer review and constructing a blockchain system framework. However, existing studies primarily address theoretical aspects such as the advantages of integration and implementation feasibility, with limited research on technical implementation. China' s policies regarding blockchain currencies (e.g., Bitcoin) differ from those abroad, making foreign research results non-transferable. A domestically appropriate open peer review system must be established. This study addresses identity registration and public participation issues in open peer review using blockchain and IPFS technology, proposes two incentive mechanisms, and offers new solutions for connecting tokens with fiat currency, constructing a fusion model of blockchain+IPFS and open peer review to provide a reference for high-quality academic review systems for Chinese scientific journals.

1.1 Blockchain

Blockchain technology, first proposed in 2008, is a decentralized distributed database characterized by transparency, immutability, and traceability [10]. In October 2016, China' s Ministry of Industry and Information Technology released the *White Paper on Blockchain Technology and Application Development in China*, aiming to introduce blockchain technology into multiple domestic domains. The *Provisions of the Supreme People' s Court on Several Issues Concerning the Trial of Cases by Internet Courts*, passed in September 2018,

marked China' s first judicial interpretation legally recognizing timestamp and blockchain-based evidence preservation methods. Blockchain enables every participant in the system to maintain the ledger, distributing activity records to others for backup, ensuring each participant possesses a complete ledger and enhancing data security.

1.1.1 Smart Contracts

Smart contracts are self-executing decentralized programs deployed on blockchain [11], possessing the general characteristics of blockchain data. Their execution process is trustworthy, with results verified collectively by all nodes. Once triggered, smart contracts execute corresponding terms, essentially eliminating external manual intervention.

1.1.2 Channel Function

Channels are private blockchains on Fabric (an open-source blockchain platform) consisting of specific node members [12]. Activities within a channel are only visible to channel members, with channel ledgers shared among all peer nodes. Transactions between channel members require identity verification, thereby achieving data isolation and transaction privacy.

1.1.3 Timestamp

When new blocks are generated in blockchain systems, they are timestamped and formed into a blockchain according to generation time. Nodes interconnect through P2P networks, forming a decentralized distributed timestamp system [13]. Timestamps cannot be modified in any way, making blockchain technology highly valuable for protecting scientific priority.

1.2 IPFS

The InterPlanetary File System (IPFS) is a suite of subprotocols that stores and searches data and files based on content, forming a peer-to-peer distributed file system [14]. IPFS uses hash tables to store data packets, dividing files into blocks indexed by cryptographic hash values and distributing them across network nodes. When users request certain data information, DHT (Distributed Hash Table) is used to locate nodes containing the hash, and after verification, all blocks are connected to obtain complete data information. IPFS essentially addresses the problem of excessive internet redundancy.

Blockchain technology and IPFS are similar but not identical. Data on blockchain cannot be altered or deleted, with data volume only increasing over time. When data volume reaches a certain level, access delays occur, affecting overall system performance. IPFS, through content addressing and deduplication mechanisms, enables more rational data storage, retrieval, and utilization [15]. Therefore, as an underlying technology, blockchain requires

IPFS support for storage, and IPFS can provide storage infrastructure for blockchain.

In summary, blockchain technology can effectively address security and trust issues in open peer review. Smart contract technology provides a fair, automatically executable technical platform for open peer review. The timestamp function can confirm academic priority issues, and IPFS can solve blockchain' s storage pain points. Therefore, applying blockchain+IPFS technology to open peer review models to construct a technologically integrated review model is theoretically feasible.

2 Research Status and Difficulties

Currently, implementation models for open peer review remain in the exploratory stage, with limited research on combining blockchain technology with open peer review. International scholar Ámbar et al. [6] constructed an interoperable open peer review system using blockchain technology, utilizing IPFS to store and share all versions of papers and peer review reports throughout the review process, making a new decentralized system for managing open peer review possible, though its implementation feasibility in China remains questionable. Choi et al. [7] developed an open peer review system using blockchain and reviewer recommendation technology, establishing a researcher-centered academic exchange platform that minimizes external interference from publishers, but with limited involvement in role authorization and access control strategies. Domestic scholar He Ying et al. [9] analyzed the internal logic of applying blockchain technology to open peer review and constructed a blockchain system framework, though difficulties remain in interoperability and academic recognition rules both within and outside the system.

The concept of open peer review is relatively mature, yet a well-established implementation model has not formed, largely due to the lack of supporting mechanisms and technologies. The main difficulties in combining blockchain technology with open peer review include: (1) Reviewer selection. With numerous researchers across disciplines, review efficiency and quality must be ensured, meaning the number of reviewers per paper should be limited and their comprehensive qualities high. Therefore, selecting appropriate reviewers is the first challenge. (2) Public participation scope. Public participation is a crucial concept in open peer review. Too narrow a scope results in insufficient participation and oversight, while too broad a scope leads to excessive invalid comments that drown out valuable feedback. Therefore, reasonably limiting public participation scope is the second challenge. (3) Participation incentives. Since blockchain displays user identity identifiers rather than real identity information, motivating all parties to actively participate in review activities while maintaining careful, objective, and fair scientific attitudes is the third challenge. (4) Storage issues. The fundamental concept of blockchain is decentralization, but its biggest problem is the inability to store large amounts of data, with high storage and maintenance costs. All information from the review process is

recorded and stored, making it difficult to delete. Solving blockchain' s storage problem is the fourth challenge.

3.1 Identity Registration and Authentication

In traditional peer review models, users must register separately for different journals, increasing both user burden and security risks. To improve convenience and security of user information registration, a universal identity account is needed to access resources across different journals. Blockchain' s decentralized, non-forgeable, and tamper-proof characteristics provide new solutions for unified identity registration and authentication.

Users must register their identities on the blockchain, including real name, educational background, research experience, honors, professional title, and research achievements, along with supporting documentation for each piece of information. After blockchain verification, users receive a unique hash value as their sole identity identifier. All activities on the blockchain, such as paper submission and review, are conducted using this hash identity. Changes or corrections to personal information require uploading correction materials. Similarly, journal editorial offices must submit materials for registration before providing services to users.

The entire identity registration and authentication process occurs on the blockchain without requiring editorial office involvement. Blockchain serves as the identity provider, with smart contracts deployed for identity authentication and user identity information and keys stored in the ledger. The "authentication" smart contract executes predefined authentication operations based on user identity information stored on the blockchain ledger, while recording authentication history in the ledger as login logs for future auditors to detect abnormal login behavior [12].

For identity authentication security, hash chain-based One-Time Passwords (OTP) are used for authentication, based on the principle of one-time passwords. Terminals/devices generating OTP dynamic passwords are called dynamic tokens, commonly including mobile app tokens, SMS tokens, and email tokens [12]. With dynamic passwords, users no longer need to regularly change passwords, making the process secure, worry-free, and cost-effective.

After successful identity registration and authentication, when a user accesses Editorial Office A (BJBA) for submission, they must undergo identity verification with BJBA. BJBA submits the authentication request to the blockchain and invokes the authentication smart contract. Only after passing authentication can access be granted. To access services from Editorial Office B, reauthentication is required. Additionally, the "log query" smart contract can be used to query login logs and detect abnormal login behavior.

3.2 Authorization Scheme

To address the scope of disclosure issues in open peer review, blockchain' s channel function can be used to achieve intelligent division and control of disclosure scope. Activities occurring within blockchain channels are only visible to channel members, effectively achieving information isolation and ensuring user privacy and security [16]. Therefore, separate authentication and authorization channels are established, connected through smart contracts. Users can set channel policies (such as member filtering) according to their needs and can redeploy smart contracts to establish new authentication or authorization methods.

Taking Academic Journal A as an example, when an author uploads manuscript information to the blockchain node corresponding to Journal A, the manuscript information is uploaded to IPFS according to the smart contract between blockchain and IPFS, and the generated hash address is fed back to the blockchain. The blockchain then determines the appropriate channel based on the manuscript' s title, keywords, and other main information according to the smart contract deployed by the editorial office. If it falls within the journal' s scope, the manuscript is sent to all relevant domain reviewers' nodes, sorted by the time experts agree to review. The top three reviewers (number set by the editorial office in the smart contract) are selected for the review activity, with reviewer identities determined based on scholars' academic achievements and reputation (see below) (determination method set by the editorial office in the smart contract). Simultaneously, the author' s identity (identity identifier), review process, and review content (including manuscript information and review reports) are visible to other scholars (the public) in the channel (but not outside the channel), enabling public oversight of the review process.

This approach constrains the editorial office' s "veto power" while ensuring review quality and operational efficiency, effectively improving the fairness and transparency of the review process.

To distinguish roles among journal editors, authors, reviewers, and the public, different permissions are granted using discretionary access control strategies based on an access control matrix (Table 1). Access control strategies are constraint mechanisms that determine whether a subject has the right to access an object, allowing legitimate users to access specified objects without bypassing controls [12].

As shown in Table 1, matrix elements represent operations authorized for subjects on objects. The access matrix strategy grants journal editors read, write, and execute powers over authors and reviewers, while authors and reviewers have only read and write powers, and the public has only read powers over all parties. It should be noted that this access control applies only to manuscripts and the review process itself; public comments and open discussions among parties are not included in this scope.

Table 1 Access Control Matrix
(The table structure shows permissions matrix between subjects and objects)

3.3 Incentive Mechanisms

In blockchain-based open peer review, all activities are conducted using identity identifiers rather than real identity information. While this solves identity and authorization issues, establishing effective incentive mechanisms is crucial to motivate all parties to actively participate in review activities while maintaining impartial, fair, and objective scientific attitudes.

3.3.1 Academic Reputation System

Academic reputation, as the academic community' s recognition and evaluation of researchers, represents a vital academic lifeline for scholars and a comprehensive assessment of their academic level, research reputation, and social contribution. Therefore, establishing an academic reputation evaluation system can effectively mitigate "moral hazards" in review activities while incentivizing individual behavior.

The academic reputation system is controlled by a "reputation" smart contract, evaluating all participants in the review activity: editorial offices, authors, reviewers, and the public, with academic reputation thresholds set for each (except editorial offices). (1) Author evaluation: Based on authors' academic ethics, manuscript quality, and performance during the review process, comprehensive evaluations are conducted by reviewers and the public (with different weightings). Notably, authors' educational and professional backgrounds must be considered to avoid over-evaluation, and authors below the threshold will not have their manuscripts sent for review. (2) Reviewer evaluation: Based on reviewers' timeliness, review quality, and performance during the review process. For timeliness: since different journals have varying review requirements, each editorial office must establish its own evaluation criteria. For example, Editorial Office A' s timeliness evaluation standards are shown in Table 2 , which can be enforced using evaluation smart contracts. After a journal' s article review is completed, the system automatically evaluates according to that journal' s timeliness standards. Review quality and process performance are evaluated by the other three parties, with the three components combined to determine the reviewer' s reputation value. Reviewers falling below the expert threshold are removed from the reviewer database. (3) Public evaluation: Based on the public' s statements and interactions during the review process, evaluated by the other three parties, with scholars below the public threshold being muted. (4) Editorial office evaluation: Based on the editorial office' s manuscript handling process and role in interactions among the other three parties, evaluated by those parties. Since reputation values are public, editorial offices with lower reputation values will automatically receive fewer and lower-quality submissions, effectively improving editorial service quality and motivation. Finally, the three

roles (excluding editorial offices) can enhance their academic reputation values through the other two roles' identities.

Table 2 Editorial Office A Review Timeliness Scoring Standards
(Scoring criteria based on review completion time: <10 days, 10-20 days, 20-30 days, 30-40 days, >40 days, with corresponding scores out of 100)

It should be noted that all evaluations must provide supporting evidence rather than simple subjective scoring. The evaluation content itself also reflects the evaluator' s academic level and ethical perspective. Therefore, evaluations made by one party on another also become evaluation objects for other parties, effectively curbing arbitrary and malicious evaluations while promoting effective and high-quality feedback.

[Figure 1: see original paper] Framework for the Integration Strategy of Blockchain Technology and Open Peer Review

3.3.2 Material Incentives

To further enhance scholars' participation enthusiasm in open peer review, material incentives are essential in addition to academic reputation rewards. If academic reputation represents "intangible" capital, material incentives represent "tangible" capital.

Since review activities occur entirely on the blockchain, token circulation and exchange for page charges, author fees, and review fees become new challenges. We propose using blockchain' s token functionality to address this. Since blockchain virtual currencies (e.g., Bitcoin, Ethereum) can be freely traded in many countries, foreign scholars face no token recognition and circulation issues when building open peer review systems. However, such systems are unsuitable for China' s national conditions because blockchain virtual currencies are not legally recognized or protected in China, and domestic scholars have yet to propose effective solutions compatible with national conditions for token circulation and trading in open peer review systems. For China' s special circumstances, we propose a new "token" scheme that is not traditional virtual currency but rather an "exclusive token." The proposal is as follows: An official body (such as the National Press and Publication Administration) could coordinate the formation of a journal alliance responsible for developing, building, and operating a journal blockchain (consortium blockchain). The alliance would issue "exclusive tokens" circulating only on this chain, with all chain members able to purchase or sell tokens (exchanged with fiat currency). All members' financial accounts would be registered with the alliance. The alliance, as a fund (token) regulatory body, would set up a regulatory account, with all inter-member currency transactions requiring approval through the alliance's regulatory account. For example, when Editorial Office A pays review fees to Reviewer B, it must submit a transaction application to the alliance and transfer tokens to the regulatory account. Only after alliance approval can tokens be transferred to Reviewer B' s account, with other inter-member transactions following the same principle.

[Figure 2: see original paper] Comparison Between Blockchain-Based Open Peer Review Model and Traditional Peer Review Model

Additionally, review reports can be published as academic achievements of reviewers alongside papers. Citations of review reports by other scholars would be treated as citations of reviewers' academic papers. For example, *Acta Psychologica Sinica* includes a "Review Comments" link after each published article, with attachments containing multi-round peer review reports and authors' responses for readers to access and learn from.

4 Conclusion

In recent years, despite global efforts to promote open science and explore mature open peer review implementation models, the scientific and publishing communities remain hesitant due to lack of support at technical and policy mechanism levels. This study integrates blockchain technology with open peer review, effectively solving identity registration, authentication, and authorization issues. Through both tangible and intangible incentive mechanisms, it enhances participation while creating effective constraints, and utilizes IPFS collaboration to solve blockchain' s storage bottleneck. We propose a new "token" concept compatible with China' s national conditions to address token circulation and trading challenges in review systems, constructing a fusion model of blockchain technology and open peer review. However, implementing this fusion model still faces significant challenges, including policy-level and infrastructure-level difficulties, as well as how to connect blockchain identity identifiers with real-world identities. The path to building a mature open peer review model remains long and arduous, requiring step-by-step solutions in the future.

References:

[1] Qu Jiansheng, Huang Kemin. The Development Logic and Future Mission of Open Science[J]. Chinese Science Bulletin, 2022, 67(36): 4312-4325.
[2] Liu Liping, Liu Chunli. Analysis of the Advantages and Disadvantages of Open Peer Review and Recommendations[J]. Chinese Journal of Scientific and Technical Periodicals, 2017, 28(5): 389-395.
[3] Wang Lin. Investigation on the Current Status of Public Disclosure of Peer Review Content in Scientific Journals and Strategic Recommendations[J]. Chinese Journal of Scientific and Technical Periodicals, 2022, 33(06): 776-783.
[4] Shi Guanzhong, Yao Ge, Wang Shuhua, et al. Analysis of the Advantages and Disadvantages of Public Reviewers in Academic Journals: A Case Study of Earth Science Journals[J]. Acta Editologica, 2016, 28(6): 547-549.
[5] Han Lei, Yang Aihui, Zhao Guoni, et al. Verification and Handling Strategies for Covert Academic Misconduct Papers[J]. Acta Editologica, 2022, 34(1): 68-71.
[6] Ámbar Tenorio-Fornés, Elena Pérez Tirador, Antonio A, et al. Decentralizing science: Towards an interoperable open peer review ecosystem using blockchain[J]. Information Processing & Management, 2021, 58(6): 102724. DOI:10.1016/j.ipm.2021.102724.

[7] Choi, D H, Seo, T S. Development of an open peer review system using blockchain and reviewer recommendation technologies[J]. Science Editing, 2021(8): 104-111.
[8] Mackey T K, Shah N, Miyachi K, et al. A Framework Proposal for Blockchain-Based Scientific Publishing Using Shared Governance[J]. Frontiers in Blockchain, 2019, 2: 19-28.
[9] He Ying, Wang Zhijun. Research on the Framework of Blockchain System for Open Peer Review[J]. Chinese Journal of Scientific and Technical Periodicals, 2023, 34(3): 259-266.
[10] Yao Qian, Zhu Yedong. Blockchain Blue Book: China Blockchain Development Report (2021)[M]. Beijing: Social Sciences Academic Press, 2021.
[11] Zhou Tao, Li Leping, Chen Ning, et al. Blockchain Security Analysis and Countermeasures[J]. Network Security Technology & Application, 2023(07): 17-18.
[12] Zhang Mingli. Research on Blockchain-Based Authentication and Authorization Methods[D]. Beijing: University of Chinese Academy of Sciences, 2020.
[13] Li Qingbo. Research on Legal Issues of Applying Blockchain Technology to Digital Copyright Protection[D]. Chongqing: Chongqing Technology and Business University, 2021.
[14] Shi Aiwu, Fu Kexun, Wei Yinzhen, et al. A Medical Data Sharing Model Based on Blockchain and IPFS[J]. Software Guide, 2023, 22(5): 109-114.
[15] Li Jiakun. An Optimized File Storage and Distribution Model Based on IPFS[J]. Software, 2023, 44(3): 134-136.
[16] Shen Chuannian. Research on Blockchain Privacy Threats and Protection Technologies[J]. Network Security & Data Governance, 2023, 42(4): 1-8.

Note: Figure translations are in progress. See original paper for figures.

Source: ChinaXiv —Machine translation. Verify with original.