International Journal of Informatics and Communication Technology (IJ-ICT)
Vol. 15, No. 1, March 2026, pp. 111~119
ISSN: 2252-8776, DOI: 10.11591/ijict.v15i1.pp111-119

Enhancing intellectual property rights management through blockchain integration

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Article Info

Article history:

Received Jun 27, 2024
Revised Jul 15, 2025
Accepted Oct 7, 2025

Keywords:

Blockchain
Decentralization
Proof of stake
Smart contracts
Zero-knowledge proofs

ABSTRACT

The generational improvement has significantly converted several industries, and the area of intellectual property rights (IPR) isn't any exception. IPRs, being as important as they are, need to be securely managed in some way. Blockchain, with its decentralized and immutable nature, gives a promising answer for enhancing the management of intellectual property (IP). This paper explores the strategic integration of blockchain generation for the control of IPR. The proposed system consists of a complete system, from registration and validation to predictive evaluation and royalty distribution, all facilitated through clever contracts. The use of zero-knowledge proofs guarantees the safety and confidentiality of sensitive information. The paper discusses the advantages and future implications of implementing this type of device.

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1. INTRODUCTION

Blockchain technology uses a distributed ledger system to ensure reliable transactions. It is characterized by four features: decentralization, autonomy, integrity, and transparency [1]. Its security is based on consensus algorithms and cryptographic protocols. It shows promise for intellectual property rights (IPR) management, as a public, peer-to-peer, encrypted, and immutable digital ledger that is decentralized [2].

Traditional IPR management systems have problems like unauthorized use, copying, infringement of intellectual properties with transparency, security and efficiency being compromised. The decentralized ledger provided by Blockchain could be the solution to overcome all these challenges as it is comprised by immutability and cryptographic protection which makes it a strong contender for solving this difficulty [3].

This research focuses on the application and use of blockchain in IP processing, record keeping, licensing and management, smart contracts and enforcement of IP rights [4]. Incorporating blockchain, the study presents a conceptual model for a decentralized, secure, and transparent IPR management system, mitigating centralized intermediaries' influence [5]. The proposed mechanism is to remove the hurdles associated with IPR with the help of the functions offered by blockchain such as customer registration, verification, predictive analysis, and royalty generation. This work adds to the existing literature on technology and IPR and provides suggestions that might be useful for several organizations, legal professionals, policy makers, and technologists.

2. PROPOSED METHOD

Blockchain technology offers advantages like decentralization, integrity, and transparency, supported by distributed ledger systems and consensus algorithms [6]. Yet, current systems face challenges in performance, speed, and reliance on centralized authorities. Diploma verification systems encounter issues in managing data updates within blockchain frameworks, alongside reliance on consensus algorithms and the need for human involvement in verification [7], [8]. The Figure 1 shows how a model blockchain that implements IP will look like.

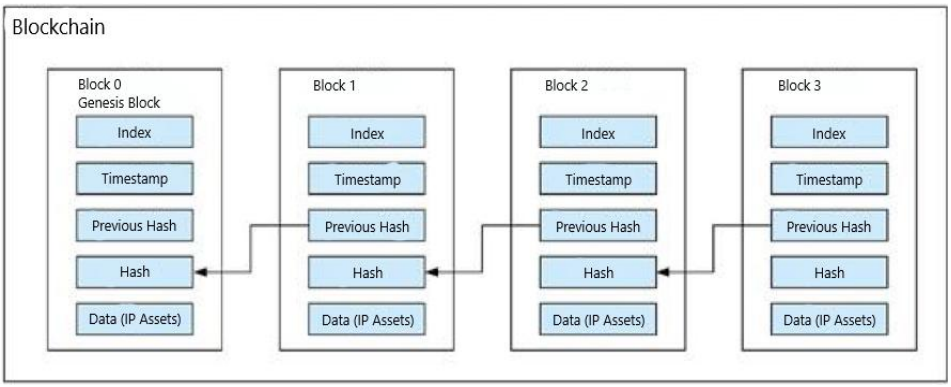

Figure 1. Structure of a blockchain for IP

IPR are vital for safeguarding creative works in diverse fields, including literature, music, art, and technology [9]. In today's digital era, concerns about fraud and piracy underscore the need for robust IPR mechanisms. Blockchain technology offers a promising solution by providing a decentralized and transparent ledger system [10]. Through smart contracts, blockchain can automate and enforce agreements, ensuring fair compensation and adherence to usage rights. This integration aligns with existing legal frameworks such as the Copyright Act, 1957, enhancing the efficiency and transparency of IPR enforcement in India [11]-[13].

The core objective of IPR is to grant creators both non-economic and economic rights, preserving their ownership and control over their intellectual assets [14]. By integrating blockchain into this framework, a decentralized and secure foundation is established to uphold these rights in the digital age. In conclusion, the incorporation of blockchain technology significantly strengthens IPR protections, offering creators resilient mechanisms to safeguard their creative works while aligning with legal regulations in India [15].

3. METHOD

This study looks into the use of blockchain technology in IPR management to improve security, transparency, and efficiency. The proposed methodology involves building a blockchain-based model that utilizes Ethereum's smart contracts to automate IPR processes such as registration, royalty distribution, and ownership transfer. Each step of the method is described below to ensure reproducibility [16].

3.1. System architecture

Here, Figure 2 depicts the functional architecture of the IPR management system. Key elements of the architecture include:

- User interface: in Figure 3. Users begin the process of creating an account after registering on the platform, ensuring secure data storage. Using cryptographic techniques improves privacy and authentication while laying the groundwork for a secure user experience [17].
- Blockchain layer: after registration, users enter critical information about their IP documents, primarily patents. This information, including inventors and filing dates, is analyzed and validated. If no matches are found, the data is securely stored on the blockchain, resulting in an immutable and traceable record was shown in Figure 4.
- Database integration: Figure 5. A comprehensive database search is used to find similar or existing IP documents. If matches are found, users are presented with relevant information about potentially related patents, allowing them to make more informed decisions.

- Blockchain-based IP documentation: in the absence of matches, IP data is securely stored and retrieved via blockchain. This district-specific ledger ensures immutable and traceable reporting, which helps to build a strong system architecture.
- Security and authentication (zero knowledge proofs (ZKP)): ZKPs are critical for authenticating IP files while preserving private information [18]. This cryptographic method improves security by verifying the authenticity of IP records.
- Automated royalty distribution (smart contracts): smart contracts distribute royalties autonomously, ensuring equity and transparency while adhering to predefined protocols. This blockchain-based mechanism speeds up the compensation process for patent owners.
- Real-time monitoring (user-friendly dashboard): a user-friendly dashboard monitors the status of IP documents in real time [19]. This user-friendly interface allows users to check for infringements, manage royalty distribution, and monitor certificate status. Cryptocurrency distributes applicable royalties to patent/IP owners, giving users more control and transparency.

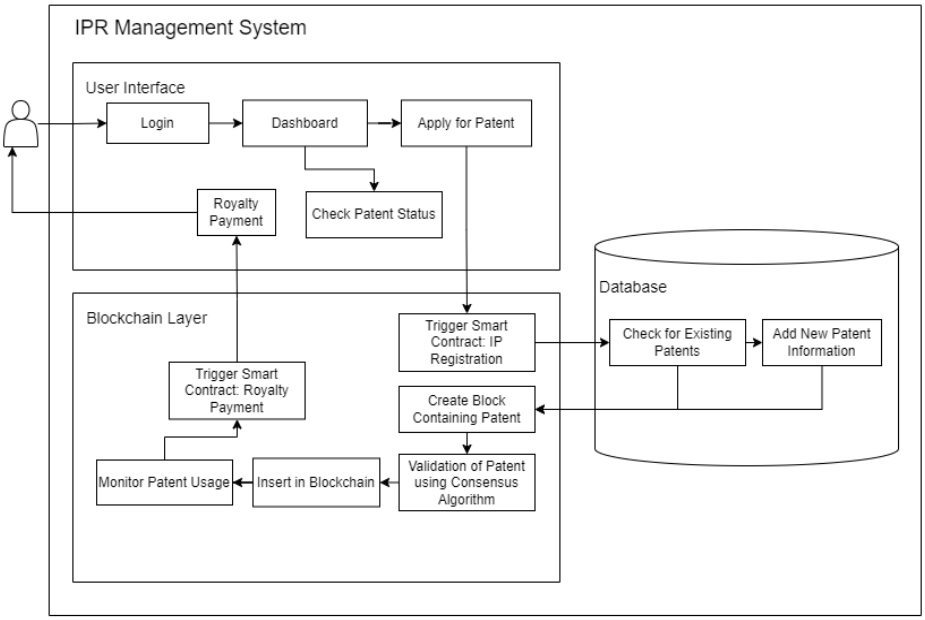

Figure 2. Functional architecture of the proposed system

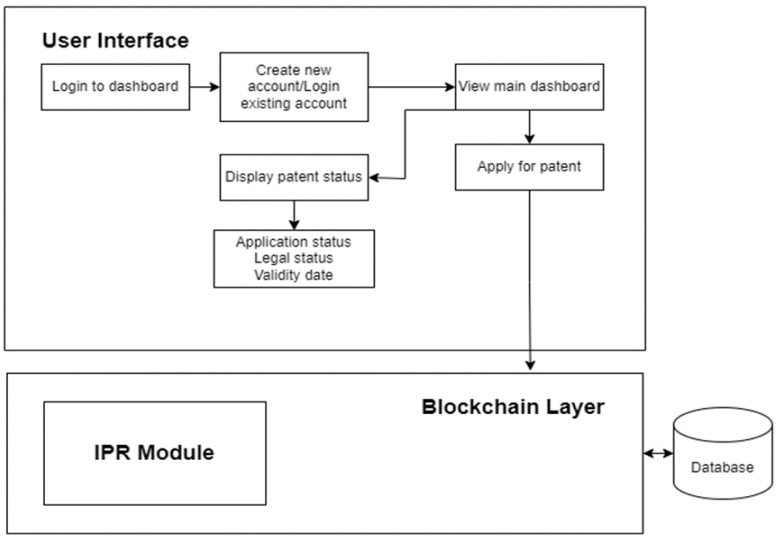

Figure 3. Functional architecture of the user interface module

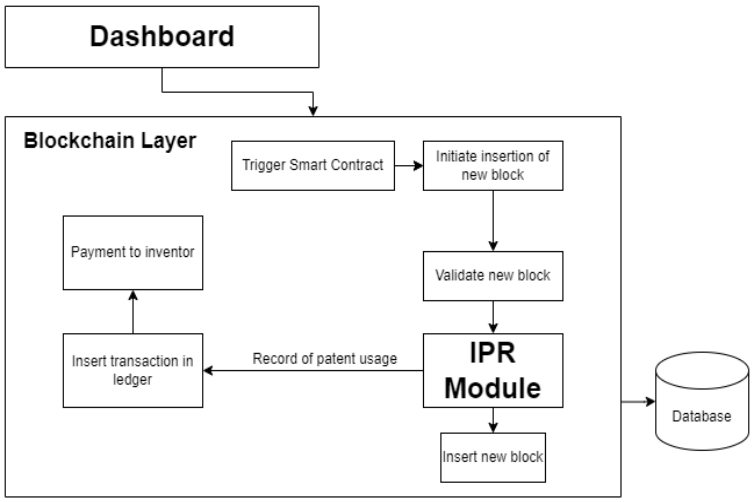

Figure 4. Architecture of the blockchain network module

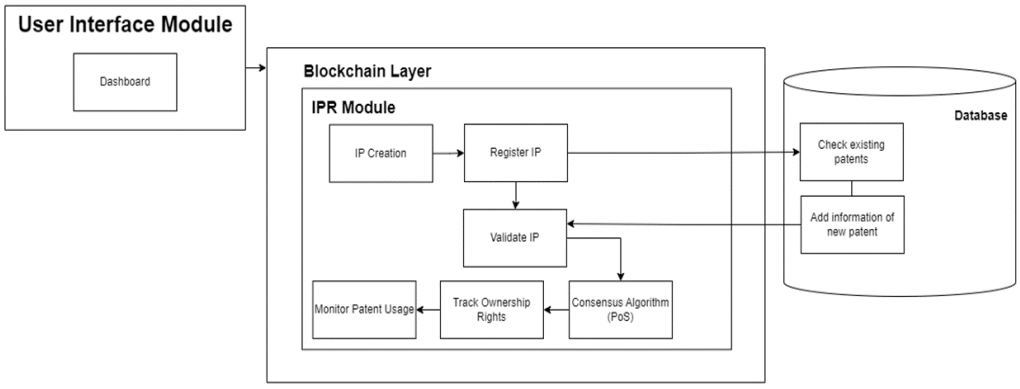

Figure 5. Architecture of the IPR module

3.2. System workflow

These components are efficiently incorporated into the workflow as seen in Figure 6:

- User interaction-users play an important role in the system workflow, starting the process by seamlessly reporting and signing in documents containing intellectual assets [20]. This user-friendly interaction not only lays the groundwork for secure IP management, but also for effective collaboration within the system.
- Blockchain insertion and database check - following user submission, the system thoroughly searches the database for existing licenses. If no match is found, the IP block is securely inserted into the blockchain, creating an immutable and decentralized record. This procedure ensures the reliability and integrity of the stored data.
- Predictive evaluation and validation-the system uses advanced zero-knowledge proofs to validate the authenticity of IP records. Simultaneously, predictive analytics evaluates the novelty of submitted documents, quickly identifying and addressing potential infringements [21]. This real-time analysis improves proactive monitoring and enforcement.
- Predictive evaluation and validation-to simplify transactions, the system assigns royalties automatically according to predetermined rules. This automated process ensures not only efficiency in royalty distribution, but also fair compensation for IP owners [22]. This feature improves the overall compensation workflow by reducing the number of manual interventions.
- Dashboard monitoring-the dashboard acts as a central hub for users to stay informed on everything from royalty distribution to potential infringements [23], [24]. This transparent and user-friendly monitoring mechanism improves engagement and satisfaction, resulting in a more seamless IP management experience.

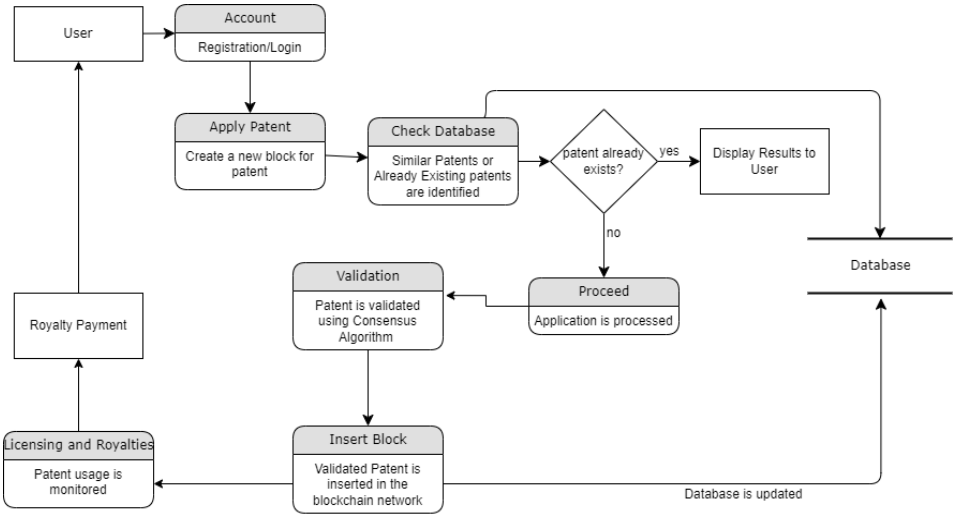

Figure 6. Proposed system workflow

3.3. Experimental setup

The system incorporates blockchain technology into IPR management through the use of Ethereum based smart contracts with Ganache and RemixIDE providing easy prototyping environments. The step-by-step process includes contract development, deployment on Ethereum, execution of agreements, automation of royalty distribution, violation detection, and secure data storage. This framework enhances transparency, efficiency, and security in IPR management.

3.3.1. IP registration and ownership transfer

A smart contract facilitates IP registration and ensures transparent ownership transfers, maintaining consistency in the process. The function 'register IP' accepts a description, increments 'nextTokenId', creates a new 'Intellectual Property' struct with the sender's address, description, and status as Registered, stores it in 'ip Registry' with 'nextTokenId', and emits an 'IP Registered' event with 'nextTokenId', sender's address, and description.

3.3.2. License agreement and royalty allocation

Smart contracts execute license agreements and automate royalty distribution based on predefined rules, ensuring fair and transparent compensation for intellectual content owners. The function 'Create License Agreement' accepts a licensee address and royalty percentage, checks if the royalty percentage is less than or equal to 100, creates a new 'License Agreement' struct with royalty percentage and sets is active to true, stores the new agreement in 'Licensing Agreements' with the next 'Agreement Id', emits a 'License Agreement Created' event with next 'Agreement Id', licensee, and royalty percentage, and increments 'next Agreement Id' [25].

3.3.3. Secure data storage and access control

SmarSmart contracts provide a secure and efficient way to manage data storage on the blockchain. They incorporate access control mechanisms that ensure only authorized individuals can view or modify sensitive information. By automating permissions and maintaining transparency, smart contracts enhance both security and trust in decentralized systems. Contracts manage secure data storage on the blockchain with access control mechanisms, ensuring that only authorized individuals can access crucial information.

3.3.4. Royalty payment

Smart contracts will make sure the inventor/creator receives the royalty payment automatically if or when their IP is used, without the need for the involvement of a third party to authorize such payment. The function 'pay Royalty' accepts 'agreement Id' as input, checks if the agreement is active, calculates the royalty Amount by multiplying the sent value with the royalty Percentage and dividing by 100, transfers the royalty Amount to the licensee, and emits a 'Royalty Paid' event with 'agreement Id', 'msg. sender', and 'royalty Amount'.

4. RESULTS AND DISCUSSION

Proof-of-stake (PoS) has emerged as a replacement for proof-of-work (PoW) in blockchain networks. The aim is to address security concerns. PoW requires significant computational powers, whereas PoS introduces a system where transactions inherently carry proof is shown in Table 1.

Table 1. Processing time

Transaction volume	PoS processing time(s)	PoW processing time(s)
100	0.12	2.04
500	0.21	3.018
1,000	0.34	4.09
2,000	0.44	5.06
5,000	0.52	6.04
10,000	0.61	7.07

Since POW is based on the computational power of the node's system unlike POS which is based on the stakes of the participating nodes, the processing speed of a transaction can be observed to be much greater in POS than in POW is shown in Figure 7. Hence it can be seen that POS's speed is higher, since not all computers have high computational power.

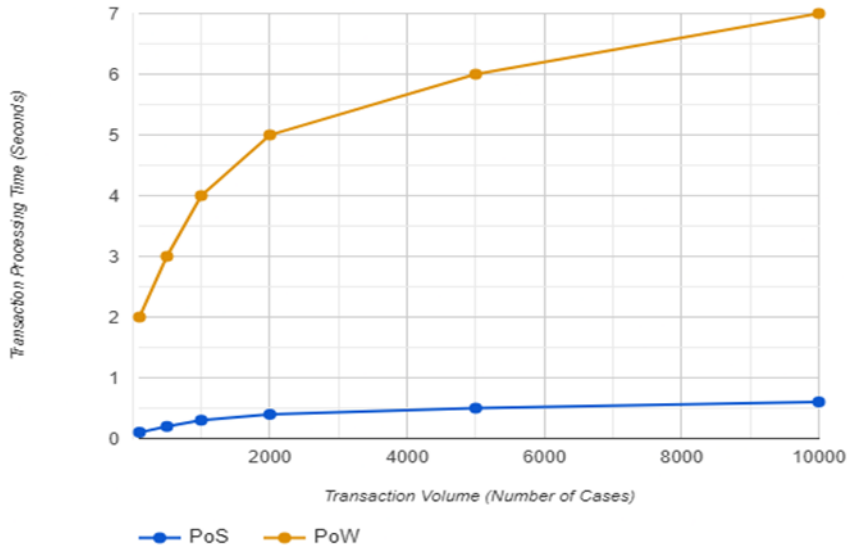

Figure 7. Comparison of PoS vs PoW transaction processing time against transaction volume

In addition to its inherent security features, PoS systems can be further fortified by incorporating IPR within the blockchain. By registering IP on the blockchain, creators establish ownership and safeguard their creative works. The results pertaining to the algorithms employed in the suggested system are compiled in Table 2, which also emphasizes the ways in which each one supports safe and effective data management.

Table 2. Representation of the findings on the algorithms used in the proposed system

Feature	PoS	ZKP
Purpose	Consensus without mining	Proves ownership cryptographically
Role in IPR management	Secure blockchain transactions	Privacy-preserving verification
Benefits for IPR management	Lower energy, faster transactions, enhanced security	Secure IP verification
Challenges for IPR management	Stake centralization risk	Design vigilance
Suitable use cases	Public or permissioned blockchains for managing publicly traded IP or IP with moderate privacy requirements	Permissioned blockchains for managing highly confidential IP or enforcing complex licensing agreements

Timestamps on the blockchain provide immutable proof of IPR registration times, which aids in dispute resolution and ownership verification. Distributed ledger technology provides tamper-proof timestamps, which are supported by smart contract audits and the PoS consensus mechanism for added security. The robustness of the suggested method is validated by the security framework's strong resistance to tampering and unauthorized modifications, as shown in Table 3.

Table 3. Representation of security analysis

Aspect	Findings
Immutable proof	Timestamps verify exact IPR registration time on the blockchain.
Dispute resolution	Secure timestamps serve as tamper-proof evidence for ownership.
Tamper detection	Distributed ledger technology ensures timestamp immutability.
Security measures	Smart contract audits and PoS consensus mechanism fortify security.
Transaction speed	Faster processing times deter timestamp manipulation attempts.

5. CONCLUSION

PoS proves to be a more secure blockchain consensus mechanism compared to PoW. By essentially embedding PoS in transactions, it utilizes coin-days to establish network stake and reduce malicious activities. Integrating IPR into this system enhances security by enabling creators to register ownership on the tamper-proof blockchain, bolstering network integrity. Future works aim at scalability, communication standards, privacy tech, and governance models, with potential enhancements from internet of things (IoT) and artificial intelligence (AI) integration. Despite promising advancements, overcoming regulatory, technical, and adoption challenges remains crucial for seamless blockchain integration in IP management.

ACKNOWLEDGEMENTS

Special thanks to our dedicated team members for their hard work in contributing to this research project. We also acknowledge the insightful contributions of the participants who helped with the testing and refinement process. We are grateful to the research community and mentors for their ongoing support and valuable insights. This article is the result of everyone’s collaborative efforts and contributions.

FUNDING INFORMATION

Authors state no funding involved.

AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

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C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

DATA AVAILABILITY

Derived data supporting the findings of this study are available from the corresponding author Raghavan Sheeja on request.

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