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A Blockchain-based Hadoop System for Enhanced IPR Management

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The Intellectual Property Rights (IPRs) management systems used today face issues majorly related to tampering, scalability, and third-party disturbances leading to disputes between the users. These disputes lead to delays and higher costs required to manage the IPRs. To solve these issues, this research proposes an integrated system using the modern digital technologies of Blockchain and Hadoop to form a Blockchain- based Hadoop system and provide an enhanced IPR Management System. A detailed methodology is provided in this research work where what are the Blockchain and Hadoop components involved and how they work together to provide this enhanced platform. For this proposed system, the Blockchain provides an immutable secure manner to store IPRs and provides transparency among all the IPR users. Additionally, Hadoop provides a highly scalable infrastructure along with various analysis and trend identification tools useful for IPR management. With the proposed system, users can manage their innovations through a reliable platform, leading to an increased number of innovations and improving the IPRs revenue worldwide. This paper also provides how the proposed system can be applied to the IPR lifecycle and its activities such as filing, approval, licensing, transfers, monitoring along other activities involved. The proposed system benefits society through its fault-tolerant approach through its immutability and decentralized mechanism providing global access for managing their innovations. Unlike the traditional systems, a faster, better, and enhanced system is provided to lower disputes among stakeholders, further leading to lowered costs and delays in processing them.

Keywords: Intellectual Property Rights, Blockchain, Hadoop, Immutability, Scalability

Intellectual Property Rights (IPR) are law- abiding rights provided to users to protect their innovations.[1] The IPR management system includes a systematic platform where all the activities such as filing, verification, approval, licensing, transfer, tracking, monitoring, etc. are provided.[2] The IPRs have motivated users to transform their creativity and provide a competitive edge in the global market valued at $ 11.43 billion in 2024, with India contributing to almost $ 1 billion in the IP landscape.[3] However, with digital technology being introduced in IPRs, its legacy needs to be aligned with modern digital technology to ensure all ill- equipped intricacies of IPRs are eradicated.[4, 5] The existing study includes Blockchain implementations for IPRs management, but further integrating it with Hadoop will remove the unwanted inefficiencies. Hence, this research provides a Blockchain-based Hadoop system for enhancing IPR management where the Blockchain mechanism provides a secure and tamper-proof mechanism and Hadoop provides a scalable platform with additional tools for managing IPRs. With individual implementations, the existing system will have limited benefits, but integrating them will provide double benefits with a more reliable and innovative platform. This research includes detailed work on what Blockchain and Hadoop components are implemented in the proposed system and how they will work together to ensure all IPR-related activities are performed smoothly to provide an enhanced system.

Blockchain Components for Proposed System

Blockchain's role in any system is to ensure the highest amount of trust, security, and automation is obtained. The immutability feature offered by a Blockchain network allows IPRs to be tamper-resistant. Unlike traditional systems that manage IPRs, the time spent for verifications is less with Blockchain. Also in the current system, the time required for all IPR management operations, be it filing, conflict resolutions, renewing, etc. a lot of time is spent where operations involved may not be timely. Blockchain on the other hand ensures all these transactions are done timely, making it justifying for

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the stakeholders to innovate more with fewer delays, providing an operational-friendly environment. The significant components of Blockchain utilized for the proposed system are as follows (Fig. 1):

(i) **Block**: All transactions performed by all stakeholders will be stored in the blocks which are linked to each other.
(ii) **Consensus Mechanism**: Agreements between the stakeholders is ensured using consensus mechanisms such as Proof of Work or Proof of Authority.
(iii) **Cryptocurrencies**: Digital assets required for filing, selling, transfer, renewal, etc. operations will be through the cryptocurrencies.
(iv) **Digital Signatures**: To validate the authenticity of the transactions performed by the participants will be using digital signatures providing data integrity.
(v) **Ledger**: The set of transparent and immutable transactions is maintained with the ledger.
(vi) **Smart Contracts**: To promote automation, smart contracts can be used for self-executing agreements between the participants.
(vii) **Timestamp**: Includes the exact date and time a block or transaction was created.
(viii) **Tokens**: The assets and rights on a certain Blockchain can be done using the token mechanism among the participants.
(ix) **Transactions**: The set of operations involving IPR management are identified as transactions.

Hadoop Components for Proposed System

Hadoop addresses a critical limitation of the current system, which is scalability. Today, the IPR management systems generate massive data including multi-media contents, patents, copyrights, legal documents, and designs which are increasing day by day, and traditional systems struggle to effectively process them. Additionally, no analysis or trend identification can be performed with the current system. Hence, this research work includes using the Hadoop technology to solve these issues along with Blockchain. The significant components of Hadoop utilized for the proposed system are as follows (Fig. 2):

(i) **HDFS**: The blocks utilized in the Blockchain will follow using the HDFS which can store large IPR data across a distributed framework.
(ii) **Flume**: The operation of collecting and segregating the transactional log data of the participants into Hadoop will be done by Flume.
(iii) **HBase**: HBase provides using NoSQL real-time database required to perform reading and writing IPR transactions.
(iv) **Hive**: Hive provides an SQL-like interface to interact with the IPRs data.
(v) **MapReduce**: The IPRs data present in the Hadoop clusters can be processed and analysed in parallel using MapReduce.
(vi) **Oozie**: The automation required in the proposed model is achieved using Oozie which schedules timely IPR transactions without any delays.
(vii) **Spark**: The in-memory processing of IPRs along with further analysis is performed by Spark.
(viii) **Sqoop**: In cases of additional databases used for IPR management, the Sqoop can transfer IPR data from Hadoop to other databases.
(ix) **Yet Another Resource Navigator (YARN)**: The IPRs management including several operations is possible due to appropriate resource allocation in the Hadoop through YARN.

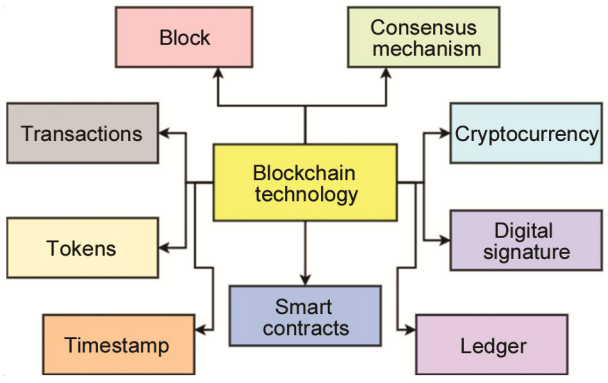

Fig. 1 — Blockchain components for Proposed System

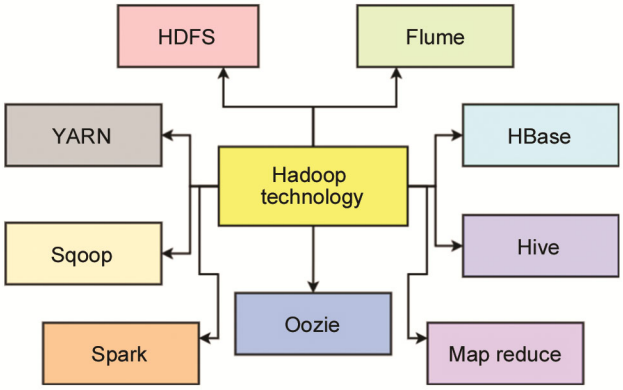

Fig. 2 — Hadoop components for Proposed System

Rationale for Blockchain-based Hadoop System for IPRs

The current IPRs management system used all over the globe offers users a fantastic way to manage their innovations and ensure they are well processed through the entire IPRs lifecycle. However, this current IPRs management system may be volatile towards tampering, considering third-party attacks, along with transparency issues, leading to a struggle to provide clear ownership, also further leading to major disputes. Additionally, the amount of IPRs managed is increasing day by day, and hence, scalability issues are often unnoticed, leading to higher cost and time consumption and inefficient data handling. Here, there becomes a need to ensure the innovations of the users are well protected and appropriate services are provided in the entire IPR lifecycle. In the modern world, modern technologies such as Blockchain and Hadoop have strengthened any systems by providing them with secure, tamper- proof, scalable solutions. These modern technologies can be applied to ensure better IPR management systems are provided to meet the heavy user demands, avoid any kind of disputes, and ensure the laws designed are well abided. When one of these technologies can assist in making IPRs stronger, together both of them can make the management of the IPRs fully reliable in security, trust, tamper-free, and scalability. These new-age technologies can increase the security and trust of the IPRs field. At the same time, the decentralized nature of blockchain also means global accessibility, facilitating stakeholders from different jurisdictions to easily interact with the system without being reliant on a central authority. Figure 3 represents the lifecycle of IPRs with the proposed Blockchain-based Hadoop system for an enhanced IPR management system.

Research Objectives

The research objectives of this paper are as follows:

(i) Performing a thorough literature review to emphasize the need for implementation of contemporary technologies in IPR management.
(ii) Proposing and formulating a Blockchain-based Hadoop system to make IPR management more efficient and reliable.
(iii) Providing a detailed integration of using Blockchain with Hadoop in managing the IPR.
(iv) Analysing the integration of Blockchain and Hadoop technologies to provide tamper-proof, secure, scalable IPR management.

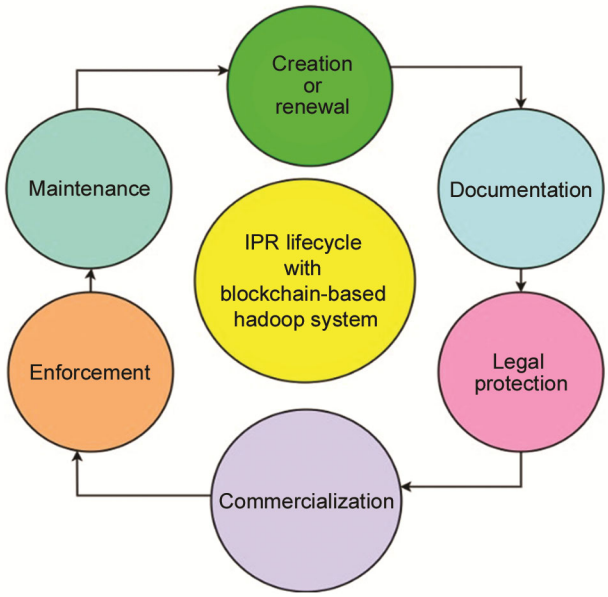

Fig. 3 — IPRs lLifecycle with blockchain-based hadoop system for enhanced IPRs management

(v) Inviting prospective researchers to pursue and integrate cutting-edge technologies to further improve the IPR management systems

Literature Review

This part involves an in-depth literature survey of diverse contributions of authors from all over the world about the improvement of IPR management. This assessment analyses the justification of IPRs in incentive theory, criticizes the exclusive-right approach, and calls for balanced, socially harmonized governance.[1] The researchers of this research paper have undertaken an exhaustive review of IPR-related contributions, offering key insights on the topic and comprehending the evolution of IPRs over time.[2] The analysis offered in this paper explores works generated by Artificial Intelligence (AI) while offering balanced governance between human beings and AI.[3]

This research explores the legal issues of accepting AI as an inventor under the existing patent system, suggests standards for AI contributions, and identifies legislative clarity needed in India.[4] Blockchain technology has been explored for the IPRs to ensure improved efficiency and increase IP innovations globally.[5] The study conducted by the authors examines how IPRs are well connected with Blockchain to improve transparency and reshape IPR management.[6] The research includes how the implementation of Blockchain is helping the IPR legal systems globally.[7] The copyright detection under the

IPRs has been focused in this research work using a blockchain-based methodology in the digital world.[8] Smart contracts of the blockchain technology are implemented to improve the IPRs management system.[9] A blockchain-based scholar network system is used to safeguard IPRs to ensure that the IPRs of academic professionals are well secured.[10] This research work uses AI with the blockchain mechanism to automate the management of IPRs.[11] The policy recommendations of IPRs to provide higher transparency and security are explored in this research paper.[12] This work ensures security through the blockchain method.[13] The authors have performed an IPRs analysis with a focus on innovations.[14]

The non-fungible tokens are focused on digital IPRs considering their legal and ethical impacts.[15] The concept of neural networks is used to redesign the IPRs management system to reduce costs for detecting infringements and trademarks.[16] This paper reviews IPR protection in the modern digital age by highlighting the role of blockchain.[17] The decentralized platform provided by blockchain supports IPR protection by providing open solutions to build a robust management system.[18] This work explores how blockchain can be applied for registering, protecting, and risk management of IPRs.[19] The study conducted examines the use of blockchain for innovations and solutions suitable for collaborations in the IPRs domain.[20] A blockchain system has been introduced to provide an innovative solution to the conventional system.[21] This paper analyses blockchain's potential for IPR management by placing challenges.[22] Blockchain's functionality is analysed for managing IPRs with an emphasis on the development of secure industrial rights.[23] A survey is conducted in this paper to assess the effect on data exchange, transactions, and societal innovation, giving an overview of its status and potential development.[24]

The use of AI with blockchain is investigated in this study to shape IPR management with an emphasis on non-registered rights and innovative ecosystems through IT industries.[25] Blockchain's capacity to solve international IP issues is assessed in this study, proposing international cooperation and IPR management regulation improvements.[26] This paper includes a complete study of analysing risks and potentials of IPRs through big data.[27] Smart contracts are analysed in digital rights management, suggesting frameworks to enhance IPR systems.[28] Security is increased through the use of blockchain to enhance transparency and data handling for IPRs.[29] A platform based on blockchain is developed for the protection of IPRs.[30] The application of blockchain's decentralized and irreversible features for IPR protection and counterfeiting detection is analyzed.[31] Blockchain integration into IPRs has been researched by the authors to enhance security.[32] This research work contributes new ideas for renewing IPRs aligning with big data innovations.[33] A review is included in this paper, discussing the intersection between blockchain technology and IPRs, with an emphasis on necessity for transparent regulatory structures.[34] A blockchain-based system is proposed to promote music IPR protection through enhanced security and transparency.[35]

This article explores blockchain's contribution to the development of energy technology by providing a focus on the energy sector and the role of transmission for patents.[36] This article discusses IP issues in Big Data applications, suggesting blockchain-enabled smart contracts as solutions for copyright and regulation.[37] This paper indicates blockchain's contribution to IPR protection in the life sciences industry.[38] This research investigates blockchain's contribution to IPR protection, highlighting enhancing copyright systems and protecting digital content.[39] The authors have discussed and considered blockchain's contribution to IP rights protection and spearheading global innovation.[40] This research study examines blockchain's potential to disrupt digital copyright protection, providing solutions to meet infringement challenges.[41] This paper identifies Hadoop's role in Big Data processing, focusing on its significance in fault tolerance, distributed systems, and analytics to revolutionize data processing.[42] Hadoop is introduced by the authors as a solution for distributed data processing.[43] This paper provides meaningful insights into Blockchain technology for patents.[44] This paper has provided versatile Blockchain applications for bringing transformative changes.[45] This study discusses blockchain's implementation in meeting IPR eligibility challenges.[46] This paper applies a blockchain-facilitated solution to augment security in distributed systems.[47] This paper discusses a consortium blockchain model to address IPR management challenges, providing insights into digital-era enforcement and globalization.[48] How the IPRs can be helped through the usage of Blockchain is provided in this work across various domains.[49] This study analyses blockchain's potential in IP

registries, focusing on decentralized platforms for record validation.[50] The IPRs management system can adapt the new modern technologies for trade and secret protections.[51] This research suggests a hybrid blockchain framework with consortium and private attributes to address challenges in managing IPRs.[52] This paper presents an integrated blockchain and IoT system for IPR protection.[53] This paper investigated how blockchain information systems improve the protection of IPRs through enhanced transparency.[54] A balance is analysed between traditional and model IPRs management systems in this paper.[55]

This study analyses blockchain's potential in IPR systems, researching studies, and potential areas for breakthroughs.[56] This paper examines blockchain's potential in solving conventional IPR protection issues by predicting patterns.[57] This research studies blockchain's potential to revolutionize legal contracts for digital IPRs.[58] This article contains an analysis pointing to the effect of blockchain on legal relations concerning IPRs in highlighting the role of ensuring efficient management.[59] The tensions present in the IPRs domain are recalibrated to harness Hadoop as a solution.[60] The authors have presented their work to ensure transparency is achieved in IPR systems.[61] This paper defines the usage of IPRs based on famous author theories for transforming IPR system models.[62] This research demonstrates blockchain's potential in harmonizing IPR systems with affordable and decentralized solutions.[63] This paper has proposed a data storage method using Hadoop to enhance patent handling.[64]

Review Considering Focus Area, Enhancement and Limitations

This section includes the survey considering Focus Area, Enhancements, and Limitations offered presented in Table 1.

Table 1 — Literature survey concerning focus area, enhancements and limitations

Ref. No.	Focus Area	Enhancements	Limitations
[1]	Analysis of IPR models with cost evaluation.	Study balances IPRs regulations.	The conducted work is theoretical.
[2]	Contribution and progressions in the IPRs journal.	Consistent methodology and covers recent works.	Literature review-based study.
[3]	Copyright and AI-human collaboration debate.	Advocates co-authorship in AI-human outputs.	Lacks case studies and implementation.
[4]	Legal and policy basis for AI inventorship.	Focus on Indian policymaking for AI patents.	Excludes technological and enforcement gaps.
[5]	Virtual asset security.	Encourages blockchain adoption for global IP.	Highlights scalability and tech challenges.
[6]	Blockchain-IPR integration issues reviewed.	Technical framework addressing gaps proposed.	Overlooks cost and scalability factors.
[7]	Blockchain for IPR register integrity.	Boosts data accessibility and system trust.	Insufficient focus on adoption challenges.
[8]	Copyright registration.	Introduces tamper-proof IPRs protection framework.	Lacks practical implementation insights.
[9]	Blockchain and smart contracts in IPRs.	Practical improvements for integration are highlighted.	Real-world hurdles are largely ignored.
[10]	Academic IPRs decentralized storage system.	Proposes secure solutions for researcher interactions.	Cost and scalability barriers are not addressed.
[11]	IPRs process efficiency.	Enhances transparency and operational management.	Implementation and scalability are unexplored.
[12]	Blockchain innovation and transparency.	Proposes solutions aiding IPR policymakers.	Lacks depth on legacy integration issues.
[13]	Blockchain for IPR management.	Improves cost-efficiency for IPRs in design industries.	Scalability unaddressed.
[14]	Assess regulatory approaches.	Introduce frameworks emphasizing protections	Navigate tensions between interests.
[16]	Neural networks in automating IPR tasks.	High accuracy in IPRs infringement analysis provided.	Overlooks scalability and uses narrow use cases.
[15]	Blockchain and AI for IPR verification.	Suggests legal updates on regulatory standardization.	Lacks detailed implementation and scalability issues.
[17]	Legislative comparison of frameworks.	Proposes balanced regulations and international cooperation.	Ethical conflicts remain unresolved.
[18]	Transparent IPR transactions.	Proposes decentralized marketplaces and royalty management.	Does not address scalability or technical challenges.
[19]	Risks in distributed IPRs.	Suggests legal frameworks to improve blockchain efficiency.	Focuses on theoretical risks; lacks case studies.

(*Contd.*)

Table 1 — Literature survey concerning focus area, enhancements and limitations (*Contd*.)

Ref. No.	Focus Area	Enhancements	Limitations
[20]	Advantages and issues in IPR management.	Highlights economic growth through stronger IPR protection.	Regulatory compatibility needs identified.
[21]	Authentication scheme using IPRs.	Enhances privacy and efficiency through decentralized storage.	Concerns related to risks, scalability, and integration.
[22]	Blockchain manages IPRs transparently.	Solutions addressing transparency and immutability issues.	Has scalability concerns.
[23]	Improving security for IPRs.	Incorporates regulations and Islamic law perspectives.	Practical adoption and scalability challenges.
[24]	Development prospects.	Provides an overview of societal and technological impacts.	Lacks specific applications.
[25]	Ledger management.	Proposes a government-backed marketplace.	Limited focus on scalability and regulatory hurdles.
[26]	Impact on IPRs and digital technologies.	Highlights transparency and innovation for IPR frameworks.	Does not explore practical challenges or scalability.
[27]	Assessing potential risks with IPRs.	Highlights the need for concrete evidence for IPR regulations.	Lacks of concept between IPRs and technology
[28]	Smart contracts in IPRs transfer.	Proposes systems for legally binding IPR management.	Consensus implementation issues with blockchain.
[29]	Security and traceability.	Leverages tamper-proof features; improves file verification.	Storage needs and scalability concerns are needed.
[30]	Blockchain and traditional methods in IPRs	Proposes improved security and efficiency using blockchain.	Practical challenges and scalability were unaddressed.
[31]	Mitigating counterfeiting.	Demonstrates transparency.	Legal adoption implementation issues noted.
[32]	Balancing IPRs privacy and transparency.	Cryptographic tools for secure and tamper-proof IPRs.	Limited exploration of scalability and implementation.
[33]	Conflict analysis of IPRs.	Blends IPRs with technologies to address its issues.	Extensive data exchange in IPRs is considered.
[34]	Stakeholder roles in blockchain adoption.	Reviews blockchain's potential in ownership and economics.	Regulation gaps and uneven stakeholder knowledge.
[35]	Music IPRs management.	Simplifies and decentralizes music IPR processes.	Limited scalability and broader applicability.
[36]	Blockchain in energy sector patenting.	Reduces reliance on central entities; enhances transparency.	Technical challenges and broader implications.
[37]	Big Data IPRs to access control.	Proposes a fair access framework with security policies.	Lacks broader Big Data applications and scalability.
[38]	Life sciences IPRs management.	Streamlines processes and safeguards intangible assets.	Does not address integration and scalability issues.
[39]	Copyright validation.	Distributed registries and encryption for IPR management.	Implementation and scalability gaps noted.
[40]	Impact on IPR sharing and growth.	Strengthens IPR frameworks and innovation access.	Lacks technical and system integration discussions.
[41]	Monitor copyright and infringement.	Proposes a unified platform for security and transparency.	Scalability and implementation challenges remain.
[42]	Hadoop for managing Big Data types.	Provides fault-tolerant, reliable data processing systems.	Limited scalability and security discussions.
[43]	Distributed platform for large-scale data processing.	Provides scalability from single server to thousand machines.	Handling large data exceeds processing capabilities
[44]	Challenges and solutions of IPRs.	Creating new IPRs through licensing.	Complexities in implementations.
[45]	Applying Blockchain Technology in Healthcare	Provides secure and transparent healthcare systems.	Problems in adapting Blockchain into multiple sectors
[46]	Blockchain in IPRs object protection.	Resolves territorial issues; enhances digital IP security.	Regulatory barriers were unaddressed.
[47]	HDFS vulnerabilities.	Uses a tamper-proof blockchain to secure file sharing.	Extra storage needs and limited scalability focus.
[48]	Blockchain for decentralization in IPR enforcement.	Proposes consortium blockchain for improved adaptability.	Scalability and regulatory issues were underexplored.

(*Contd*.)

Table 1 — Literature survey concerning focus area, enhancements and limitations

Ref. No.	Focus Area	Enhancements	Limitations
[49]	Revolutionizing traditional systems for IPRs	Enhanced scalability and streamlined operations.	Integrating challenges with existing systems.
[50]	Blockchain registries improving IPRs transparency.	Proposes permissioned and permissionless registries.	Dispute resolution mechanisms need development.
[51]	Challenges in legal patent frameworks.	Provided provisions for Text and Data Mining.	Issues with a variety of data in Patent systems.
[52]	Hybrid blockchain for digital asset authenticity.	Transparent, secure access control in IPR management.	Interoperability challenges were not detailed.
[53]	Blockchain-IoT integration for IPRs protection.	Proposes ecological systems using blockchain and IoT.	Scalability, implementation, and interoperability gaps.
[54]	Transparency and security for IPR registries.	Simplifies registration with government-authorized validation.	Requires technical and legal solutions for disputes.
[55]	Examining IPRs in fostering monopolies.	Introducing newer methods to disrupt IPR malpractices.	Challenges with adapting to new presented methods.
[56]	Addressing IPR sector.	Highlights transformative potential and research directions.	Technical and scalability concerns were underexplored.
[57]	Copyright evidence and cost issues.	Proposes solutions to enhance efficiency and reduce delays.	Latency and scalability challenges were unexplored.
[58]	Streamlining digital IPRs management.	Tamper-proof systems for secure IPR rights management.	Lacks complexities of legal and implementation.
[59]	IPRs risk protection during processing data.	Identification of risks related to infringements.	Complexities in safeguarding IPRs.
[60]	Issues of big data use for IPRs.	Increased transparency in healthcare data.	Presence of legal challenges.
[61]	IPRs commercialization reduction.	Advocates national blockchain adoption for rights protection.	Limited focus on regulatory and scalability hurdles.
[62]	Analysing Blockchain capacity for IPRs.	Replaced traditional property methods with Blockchain.	Issues of implementing Blockchain in IPRs.
[63]	Blockchain replacing traditional IPR databases.	Decentralized IPRs registration and maintenance; cost savings.	Scalability and legal standardization challenges noted.
[64]	Enhancing patent management systems.	Increased query performance by double.	Requires adjustment with existing methods.

Research Gap

The detailed review conducted helped the authors to frame the following research gaps:

1. Lack of understanding of how Blockchain can be combined with Hadoop for managing IPRs.
2. Lack of Hadoop integration with Blockchain leaves gaps in scalability and data handling.
3. Limited research on aligning legal frameworks and policy standardization with this integration.
4. Absence of Blockchain-Hadoop integration with legacy databases creates structural barriers.
5. Unexplored cost implications challenges hinder implementation in the IPRs domain.

Proposed Blockchain-based Hadoop System for IPR activities

This section includes a detailed understanding of what components of Blockchain and Hadoop will work together to provide the combined efforts to manage the activities involved in the management of IPRs in the proposed Blockchain-based Hadoop system, presented in Fig. 4. The IPR activities include filing the IPRs, verification, and approval of IPRs, IPRs ownership and registration process, licensing and royalty agreement processes, IPRs usage tracking and monitoring, transfer or sale of IPRs, enforcement and dispute resolution of IPRs and data analysis and reporting of IPRs.

The step-wise activities followed for the management of IPRs are provided as follows:

(i) **Filing of IPRs**: The user submits an IPR application for a certain patent, trademark, or copyright. The Blockchain records the timestamp of this new IPR submission in a new block and takes the digital signature of the user. Hadoop stores all the IPR-related documents and images in its HDFS.

(ii) **Verification and Approval:** Post receiving the IPRs filing, the Blockchain verifies the new submission using its consensus mechanism. Hadoop's MapReduce processes this new IPR registration and validates the records. Once verified an approval is provided and recorded in the block of the Blockchain.

(iii) **IPRs Ownership Registration:** The ledger of the Blockchain records the ownership details with the

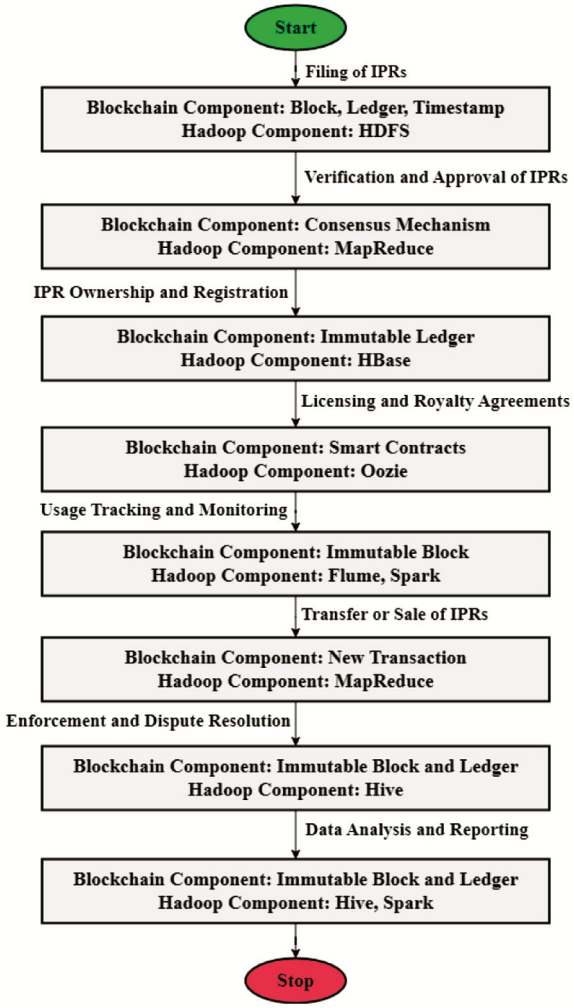

Fig. 4 — IPRs management system with Blockchain- based Hadoop System.

data being immutable. Parallelly, the HBase maintains the metadata belonging to the owner and IPRs.

(iv) **Licensing and Royalty Agreements:** Smart contracts are utilized to automate the IPRs licensing with the distribution of royalties. Along with this, Oozie schedules the licensing workflows in Hadoop.

(v) **Usage Tracking and Monitoring:** Blockchain records all the transactions immutably and securely. Flume and Spark collectively can be utilized to collect, process, and analyse real-time IPR usage.

(vi) **Transfer or Sale of IPRs:** In case of transfer of IPRs, the proposed system records it as a new transaction. Map Reduce takes charge of ownership transfer and updates the databases.

(vii) **Enforcement and Dispute Resolution:** The ledger being immutable in nature ensures the legal authenticity of the IPRs. Hive can be used for search and identification of IPR ownership. In case of any legal actions needed, smart contracts can be used for automated legal actions, if required for infringements.

(viii) **Data Analysis and Reporting –** Hive and Spark provide fast analysis of IPR data and reporting on IPRs usage, its revenue or trends. Hadoop ensures enough scalability is provided for processing IPRs analysis and reporting.

Thus, the above-mentioned activities involved in the IPRs management system can be handled smoothly using the proposed Blockchain-based Hadoop System. The proposed system thereby provides the end-user with a tamper-proof, immutable, secure, and scalable platform to manage the IPRs, leading to an enhanced IPRs management system.

Application of Blockchain-based Hadoop Technology to Facilitate Ease of IPR Use

This section includes the proposed Blockchain-based Hadoop system for enhanced IPR management. Rather than using Blockchain or Hadoop individually to improve the IPRs management system, their working mechanism is combined to design and develop a Blockchain-based Hadoop system. This system possesses all the above-mentioned components of Blockchain and Hadoop for smooth and timely functions of the IPRs management system. The proposed Blockchain- based Hadoop system is utilized for all the significant operations of IPRs which include registrations of IPRs, transfer of ownership, licensing and royalty management, Tracking and Monitoring IPR usage, and Dispute Resolution and Compliance, provided in separate sub-sections.

Registrations of IPRs with Proposed System

The IPRs that are to be filed, either in the form of a patent, trademark, copyright, etc. will be stored in a Block of the Blockchain network. These Blocks will be stored in an HDFS to ensure all the IPR data distributed across multiple nodes facilitates redundancy along with a fault-tolerance mechanism. All the blocks will record significant information about the IPRs such as their registration number, owner details, dates of registration, and expiry. These blocks are immutable providing a transparent and secure platform for storing all the IPRs. The digital signatures will also be used for user registration of IPRs, owner authentication and to verify the

legitimacy of all transactions made by the users to ensure they come from rightful owners.

Transfer of Ownership with Proposed System

If a certain IPR is to be transferred from one owner to another, a new transaction is to be created on the Blockchain network where a link is established between the current IPR owners with the new IPR owner. This will ensure the IPRs transfer is recorded in an immutable, transferable, and verifiable way. The Blockchain mechanism will use the Proof of Work of Proof of Authority consensus mechanism to validate this transfer transaction. MapReduce can be used if a large IPRs data is to be transferred involving calculations of royalties or identifying any trend in the IPRs transfer. Additionally, the MapReduce can be used to make the transfer transactions efficiently across the Hadoop cluster. Here, YARN will provide adequate resources to process the transfer transactions between the current and new owners allowing a smooth transfer without resource bottleneck.

Licensing and Royalties with Proposed System

The proposed system provides an automated process for Licensing and Royalties, unlike the traditional systems. The blockchain's smart contracts can be created to automate the licensing agreements. Once an IPR asset is provided a license, the smart contract will automatically trigger royalty payments to the IPR owner. In the case of payments, existing currency transfer is possible or cryptocurrencies can be used for the licensing payments. The concept of tokens can also be applied to represent a fraction of ownership or royalties due to the IPR owner. The amount of license or royalties can be obtained by using Hive which provides an SQL-like interface to query the IPRs data stored in the Hadoop clusters. The reports generation required during processing license fees, and royalties, along with the transaction histories related to IPRs can be managed using Hive. Alongside Hive, Flume can be used to collect real-time log data including IPR usage statistics, and IPR sales data which can be fed into Hadoop for further analysis and improved decision-making.

Tracking and Monitoring Usage with Proposed System

The blockchain's ledger can be used to keep all the immutable IPRs and all transactions related to all IPRs. This includes its history related to its usage, licensing, and transfer transactions. This will guarantee that all the IPRs are safe through all of its lifecycle. Any kind of update happening concerning IPRs will be quickly informed to all the participants in the Blockchain network, keeping all the IPRs data synchronized and accurate. For monitoring the usage, Apache Spark can be used which has the potential for real-time data processing and analysing trends in the IPRs management helping its owners track the performance of their assets and make data- driven intelligent decisions. The HBase can be used to store real-time data about the IPR usage statistics, its sales, or licensing enforcement. This data can be analysed by other participants in the Blockchain network.

Dispute Resolution and Compliance with Proposed System

The chances of disputes are near zero with the proposed Blockchain-based Hadoop system for IPR management. Here, the digital signatures will ensure all transactions are validated preventing any kind of fraud or unauthorized alterations of the IPR data. Also, the Blockchain network uses the timestamp feature providing an exact record of when and what was done with the IPRs, which becomes critical in case of legal disputes. The Hadoop's Oozie can be deployed to schedule regular compliance checks ensuring IPRs are kept up-to-date and compliant with regulations. Here, Hadoop's Sqoop can also be used to help transfer IPR data from relational traditional databases into the Hadoop present in the proposed system for comprehensive analysis and auditing.

Data Analytics and Reporting with Proposed System

The consensus mechanism present in the proposed system ensures only valid transactions are included in the Blockchain network. This will ensure that the data is included for validation making it more reliable and trustworthy. The analytics can be done using the MapReduce component of Hadoop which can help analyse trends in the IPRs filings, transfers, usage statistics, or litigation cases. The reporting can be smoothly performed using the Hive where the IPRs are stored in HDFS clusters, helping the performance of IPR management to be more. Additionally, Apache Spark can be used to provide real-time analytics along with reporting, further helping generate more revenue for IPRs.

Conclusion

The Intellectual Property Rights (IPRs) management systems being used today face issues majorly related to tampering, scalability, and third- party disturbances leading to disputes between the users. Additionally, the number of IPRs filed and managed is increasing day by day making these issues worse, especially with existing IPR management systems functioning without modern

digital technologies. To solve these issues, this research proposes an integrated IPR management system using the modern digital technologies of Blockchain and Hadoop to form a Blockchain-based Hadoop system to provide an enhanced IPR management system. The proposed system provides a tamper-free platform through Blockchain where IPRs are stored in an immutable manner providing security and transparency among all the users. Additionally, Hadoop provides a highly scalable infrastructure along with various analysis and trend identification tools needed for IPR management. The application of the proposed system is presented considering the IPR lifecycle along with all its activities conducted. With each implementation, how the entire IPR system will benefit is provided with the integration of the Blockchain component with the Hadoop component. With the proposed Blockchain-based Hadoop system, users can now manage their innovations securely and reliably, leading to an increased number of innovations and improving IPR revenue worldwide. The proposed Blockchain-based Hadoop system provides a decent approach through its immutability and decentralized mechanism providing global access for managing their innovations. Unlike the traditional system, a faster, better, and enhanced system is suggested to direct IPR management leading to lower disputes among stakeholders, further leading to lowered costs and delays in IPR processing using the proposed Blockchain-based Hadoop IPR management system. Further, it is suggested to implement a Quantum- Computing-based system with the proposed system to ensure IPR management is a faster and more reliable system than the traditional system.

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