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"Jnana Sangama", Belgaum - 590014, Karnataka

BLOCKCHAIN AAT REPORT

on

Decentralized Intellectual Property Registry

Submitted by

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Under the Guidance of
Prof. [Guide Name]
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in

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Bull Temple Road, Bengaluru - 560019
(Affiliated to Visvesvaraya Technological University, Belgaum)

Department of Computer Science and Engineering

CERTIFICATE

This is to certify that the AAT work entitled "Decentralized Intellectual Property Registry" is carried out by Student Name 1 (USN1), Student Name 2 (USN2), Student Name 3 (USN3), Student Name 4 (USN4), who are bonafide students of [Institution Name]. It is in partial fulfillment for the award of Bachelor of Engineering in Computer Science and Engineering of the Visvesvaraya Technological University, Belgaum, during the year 2024-2025. The AAT report has been approved as it satisfies the academic requirements in respect of Blockchain (23CS6PEBLC) work prescribed for the said degree.

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DECLARATION

We, Student Name 1 (USN1), Student Name 2 (USN2), Student Name 3 (USN3), Student Name 4 (USN4), students of 6th Semester, B.E., Department of Computer Science and Engineering, [Institution Name], Bengaluru, hereby declare that this AAT entitled "Decentralized Intellectual Property Registry" has been carried out by us under the guidance of Prof. [Guide Name], Assistant Professor, Department of CSE, [Institution Name], Bengaluru, during the academic semester February 2025 to June 2025.

We also declare that, to the best of our knowledge and belief, the development reported here does not form part of any other report by any other students.

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Chapter 1

Introduction

The rapid digitization of creative industries has transformed the way intellectual property (IP) is created, shared, and monetized. From digital art and music to software and literature, content creators face significant challenges in protecting their work from piracy, unauthorized distribution, and disputes over ownership. Traditional IP management systems, often centralized and reliant on intermediaries like copyright offices or licensing agencies, are prone to inefficiencies, high costs, and vulnerabilities such as data tampering or loss. To address these issues, the Decentralized Intellectual Property Registry project leverages blockchain technology to create a secure, transparent, and immutable platform for managing digital content ownership and rights.

This project introduces a decentralized application (DApp) built on the Ethereum blockchain, integrated with a robust frontend and backend infrastructure. By utilizing smart contracts and decentralized storage, the system ensures that creators retain control over their intellectual property, while consumers can securely purchase and verify ownership of digital content. The platform aims to revolutionize IP management by eliminating intermediaries, reducing costs, and enhancing trust through transparency and immutability.

0.1 Problem Statement

In the digital age, managing intellectual property rights presents several challenges. Centralized databases, commonly used by traditional systems, are vulnerable to cyberattacks, data breaches, and unauthorized modifications. For instance, piracy remains a significant issue, with digital content such as music, e-books, and software being illegally distributed without compensating creators. Additionally, the lack of transparency in ownership records often leads to disputes, requiring costly legal interventions. Content creators also face barriers in proving ownership or enforcing licensing agreements, particularly in cross-border scenarios where jurisdictional differences complicate matters.

Moreover, centralized systems often impose high administrative costs and delays in processing IP registrations or transfers. For example, registering a copyright or trademark can take months and involve substantial fees. These inefficiencies hinder creators, especially independent artists or small-scale developers, from protecting and monetizing their work effectively. The Decentralized Intellectual Property Registry seeks to address these issues by providing a blockchain-based solution that ensures secure, transparent, and efficient management of digital content ownership and rights.

0.2 Motivation

The motivation for this project arises from the need to modernize intellectual property management in response to the limitations of traditional systems. Key drivers include:

- Protection Against Piracy: By recording ownership on an immutable blockchain, the system prevents unauthorized distribution and provides verifiable proof of ownership.
- Transparency and Trust: Blockchain's transparent ledger ensures that all transactions, such as content submissions or purchases, are traceable, fostering trust among creators and consumers.
- Cost Efficiency: Eliminating intermediaries like licensing agencies reduces administrative costs, making IP management accessible to independent creators.
- Creator Empowerment: The platform allows creators to retain control over their content, including the ability to set licensing terms and manage access permissions.
- Global Accessibility: A decentralized system enables seamless cross-border IP management, addressing jurisdictional challenges and enabling global reach for creators.

These factors highlight the need for a decentralized solution that leverages blockchain's unique properties to transform IP management.

0.3 Objectives

The primary objectives of the Decentralized Intellectual Property Registry project are:

- To develop a decentralized platform for secure storage and management of digital content using Ethereum and IPFS.
- To ensure transparent and immutable records of content ownership and licensing agreements through smart contracts.
- To facilitate secure and efficient transactions for purchasing or licensing digital content.
- To create a user-friendly interface that enables content creators and consumers to interact seamlessly with the platform.
- To ensure compliance with data privacy and IP regulations, providing a legally viable solution for real-world adoption.

0.4 Scope

The project focuses on developing a prototype DApp that supports:

- Content creators uploading and registering digital assets (e.g., images, music, documents) on the blockchain.
- Consumers purchasing or licensing content with secure, transparent transactions.
- Decentralized storage of content metadata and files using IPFS.
- A user interface for browsing, managing, and verifying IP assets.

The prototype serves as a proof-of-concept, with potential for future enhancements to support broader applications, such as integration with existing IP registries or support for additional blockchain networks.

Chapter 2

Methodology

The methodology for developing the Decentralized Intellectual Property Registry involves a structured approach to designing, implementing, and testing a blockchain-based DApp. This section outlines the system architecture, implementation details, the relevance of blockchain technology, and the design of smart contracts.

0.5 System Architecture

The system is designed as a full-stack application with three main components: the frontend, backend, and blockchain layer.

- Frontend: Built using React, the frontend provides a user-friendly interface for creators and consumers. It includes dashboards for managing content, searching assets, and viewing transaction histories. Libraries like Axios handle API requests, while Recharts is used to visualize data, such as content ownership trends or transaction volumes.
- Backend: The backend, powered by Node.js and Express, serves as the intermediary between the frontend and the blockchain. It processes user requests, manages MongoDB for storing user profiles and content metadata, and interacts with smart contracts via Web3.js or Ethers.js.
- Blockchain Layer: The Ethereum blockchain hosts smart contracts written in Solidity, which manage content registration, ownership verification, and transactions. IPFS is used for decentralized storage of content files, with cryptographic hashes stored on-chain for verification.

This architecture ensures a seamless flow of data between the user interface, server-side logic, and blockchain operations, maintaining security and decentralization.

0.6 Implementation Details

The implementation process involves the following key steps:

1. Frontend Development: The React-based frontend includes components for user authentication, content upload, and asset browsing. Users connect their Ethereum wallets (e.g., MetaMask) to interact with the blockchain. The interface displays content metadata, ownership details, and licensing options, with visualizations powered by Recharts for analytics.

2. Backend Development: The backend, built with Node.js and Express, handles HTTP requests from the frontend. It stores user profiles and non-sensitive metadata in MongoDB, ensuring quick access to data. The backend communicates with Ethereum smart contracts using Ethers.js, enabling operations like content registration or purchase.

3. Smart Contract Development: Smart contracts, written in Solidity, are deployed using Hardhat. They include functions for submitting content, approving or rejecting submissions, transferring ownership, and verifying authenticity. Access control mechanisms ensure that only authorized users (e.g., content creators or administrators) can perform sensitive operations.

4. Decentralized Storage: IPFS is used to store digital content files off-chain, reducing Ethereum gas costs. Content hashes are stored on the blockchain, linking files to their metadata and ensuring immutability.

5. Integration: The frontend, backend, and blockchain layers are integrated to provide a cohesive user experience. For example, when a creator uploads content, the backend stores metadata in MongoDB, the file is uploaded to IPFS, and the smart contract records the ownership details on Ethereum.

0.7 Blockchain Relevance

Blockchain technology is critical to the project's success due to its unique properties:

- Immutability: Once content ownership is recorded on the blockchain, it cannot be altered, ensuring a tamper-proof record of IP rights.
- Decentralization: By eliminating reliance on centralized servers, the system reduces the risk of data loss or unauthorized access.
- Transparency: All transactions, such as content purchases or ownership transfers, are recorded on a public ledger, providing verifiable proof of actions.
- Security: Smart contracts enforce access control, ensuring that only authorized parties can interact with specific content or functions.
- Global Accessibility: The decentralized nature of the blockchain enables creators and consumers worldwide to use the platform without jurisdictional barriers.

These features make blockchain an ideal solution for managing intellectual property in a secure and transparent manner.

0.8 Smart Contract Design

The smart contracts are designed to handle the core functionalities of the DApp. Key data structures and functions include:

- Data Structures:
  - struct Content: Stores metadata such as content ID, creator address, title, description, IPFS hash, and timestamp.
  - mapping(uint256 => Content): Maps content IDs to their metadata.
  - mapping(address => bool): Tracks authorized administrators or moderators.
- Core Functions:
  - submitContent(...): Allows creators to register new content, storing metadata and IPFS hash on-chain.
  - approveContent(contentID): Enables administrators to approve or reject content submissions.
  - purchaseContent(contentID): Facilitates secure payment and ownership transfer for content purchases.
  - verifyOwnership(contentID): Returns the current owner of a content item for verification.
- Security Measures:
  - onlyOwner modifier: Restricts administrative functions to the contract owner.
  - onlyAuthorized modifier: Limits content approval to authorized moderators.
  - Event logging: Records all transactions (e.g., content submission, purchase) for transparency.

The contracts are deployed on the Ethereum Sepolia testnet for development and testing, with plans for mainnet deployment in production.

Chapter 3

Results and Discussion

The Decentralized Intellectual Property Registry prototype was successfully implemented and tested, demonstrating its potential to transform IP management. This section discusses the system's functionality and testing outcomes.

0.9 System Functionality

The DApp provides a robust set of features for content creators and consumers:

- Content Registration: Creators can upload digital assets (e.g., images, music, documents) via the React interface. Files are stored on IPFS, and metadata, including the IPFS hash, is recorded on the Ethereum blockchain.
- Ownership Verification: Consumers can verify the authenticity and ownership of content using the verifyOwnership function, ensuring trust in transactions.
- Secure Transactions: The purchaseContent function enables consumers to buy content, with payments processed in Ether and ownership transferred via smart contracts.
- User Interface: The frontend provides dashboards for creators to manage their assets and for consumers to browse available content. Visualizations, such as ownership trends, are displayed using Recharts.

The system successfully maintains an immutable record of ownership, with all transactions logged transparently on the blockchain.

0.10 Testing Outcomes

Comprehensive testing was conducted using Hardhat and Chai to ensure the reliability and security of the smart contracts. Key test cases included:

- Content Submission: Verified that creators can submit content, with metadata and IPFS hashes correctly stored on-chain.
- Content Approval: Tested the approveContent function to ensure only authorized moderators can approve or reject submissions.
- Content Purchase: Confirmed that the purchaseContent function transfers ownership and processes payments accurately.

- Ownership Verification: Validated that the verifyOwnership function returns the correct owner for a given content ID.
- Access Control: Ensured that unauthorized users cannot perform restricted actions, such as approving content or accessing sensitive data.

All test cases passed, confirming the system's functionality and security. The frontend and backend integration was also tested, ensuring seamless interaction between components.

0.11 Discussion

The results highlight the effectiveness of blockchain technology in addressing IP management challenges. The immutable ledger ensures that ownership records are tamper-proof, while IPFS provides scalable storage for digital content. The use of smart contracts automates processes like content approval and purchase, reducing reliance on intermediaries and lowering costs. The user-friendly interface enhances accessibility, making the platform viable for both technical and non-technical users.

However, challenges remain, such as Ethereum's high gas fees and limited transaction throughput. These issues can be mitigated in future iterations by adopting Layer 2 solutions or alternative blockchains with lower costs.

Chapter 4

Conclusion and Future Work

0.12 Conclusion

The Decentralized Intellectual Property Registry project successfully demonstrates the potential of blockchain technology to revolutionize IP management. By leveraging Ethereum smart contracts and IPFS, the DApp provides a secure, transparent, and decentralized platform for managing digital content ownership and rights. The system addresses key challenges, such as piracy, lack of transparency, and high administrative costs, by ensuring immutable records, secure transactions, and creator control. The prototype establishes a strong foundation for modernizing IP management, offering a scalable and accessible solution for content creators and consumers.

0.13 Future Work

To enhance the platform's scalability and real-world applicability, future work includes:

- Scalability Improvements: Integrate Layer 2 solutions like Polygon or zk-Rollups to reduce gas fees and improve transaction speed.
- Regulatory Compliance: Incorporate features to comply with IP and data privacy regulations, such as GDPR or copyright laws.
- Enhanced User Experience: Develop mobile applications and multi-language support to improve accessibility.
- Integration with Existing Systems: Create APIs to integrate with traditional IP registries or content platforms, enabling broader adoption.
- Support for Multiple Blockchains: Explore compatibility with other blockchains, such as Binance Smart Chain or Solana, to enhance flexibility.

These enhancements will ensure that the platform is practical, user-friendly, and ready for real-world deployment.

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