# A Blockchain Enabled Solution for Royalty Tracking in Movies and Music Industry

Mohit Mittal[1][a], Khandakar F. Rahman [1][b], C. K. Jha [1][c], Vikram Bali[2][d] and Tejaswi Khanna[3][e]
[1]*Banasthali Vidyapith, Banasthali, India*
[2]*Galgotias College of Engineering, Greater Noida, India*
[3]*Amity School of Engineering and Technology, Amity University Uttar Pradesh, Greater Noida, India*

Keywords: Blockchain, Ethereum, Smart Contract, Music, Royalties

Abstract: Managing rights and revenues is a persistent issue for the music industry. The sales of digital music tracks and albums must be more transparent between the music artist, the administrator, and other stakeholders. This usually results in the artists needing to receive just compensation in royalties. This study suggests a blockchain enabled online music publication and sales framework. The idea behind the solution is to use Ethereum Blockchain intelligent contracts to control music track sales and ensure that the artist(s) and the administration have agreed upon the payment distribution in cryptocurrency. The platform gives music artists, the administration, and other stakeholders more leverage by offering an automated, transparent, and impenetrable mechanism for tracking, administering, and distributing royalties.

## 1 INTRODUCTION

In its evolution towards digital distribution, the music industry has encountered persistent challenges in managing rights and royalties (Sharma, 2018), (Obi, 2023). Major obstacles to staying current with the consequences on licensing and royalties payout for artists, labels, publishers, composers, and streaming service providers accompany the widespread shift from tangible forms, such as CDs, to online streaming services. Numerous infringements and difficulty confirming and securing digital rights are issues the field of digital copyright protection must deal with (Shen, 2021). The opaque nature of digital music sales often leads to discrepancies in the distribution of royalties among music artists, administrators, and other stakeholders (Bali et. al, 2021). This recurring issue has prompted exploring innovative solutions to ensure fair and transparent compensation for artists.

### 1.1 Music Distribution and Royalties

This platform seeks to redefine the relationships between music artists, administrators, and various stakeholders, providing a fair and verifiable system for allocating royalties. The dearth of a consistent and transparent process for tracking sales and allocating royalties has frequently resulted in music artists losing their fair part. This issue, as shown in Figure 1, is exacerbated by the intricate network of agreements, licenses, andintermediaries involved in the music industry.

The solution to automate and authenticate the full lifetime of music track sales has been offered through the use of self-executing contracts using the Ethereum Blockchain (Oliva et. al, 2020). Smart contracts, acting as self-executing agreements, encode the rules and conditions the artists and administrators agreed upon, ensuring each party receives their fair share of royalties.

[a] https://orcid.org/0000-0002-0611-4792
[b] https://orcid.org/0000-0001-7758-5172
[c] https://orcid.org/0000-0002-5002-3134
[d] https://orcid.org/0000-0002-2809-8455
[e] https://orcid.org/0000-0003-0029-2827



Mittal, M., Rahman, K. F., Jha, C. K., Bali, V. and Khanna, T.
A Blockchain Enabled Solution for Royalty Tracking in Movies and Music Industry.
DOI: 10.5220/0013237800004646

In *Proceedings of the 1st International Conference on Cognitive & Cloud Computing (IC3Com 2024)*, pages 57-67
ISBN: 978-989-758-739-9

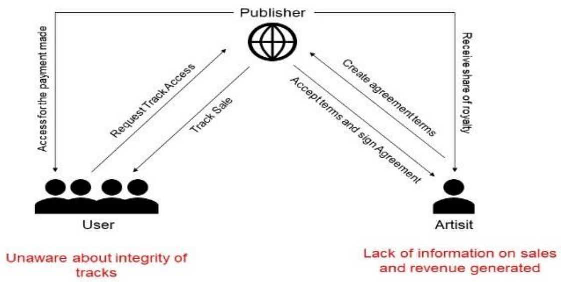


Figure 1: Current Music Stores

In this article, the researchers demonstrate how blockchain technology may successfully address the issue facing the traditional publishing industry. One area where blockchain holds the opportunity to influence significantly is the online sale of music songs (Sitonio and Nucciarelli, 2018). This platform's primary goals are to ensure that customers obtain original content and protect creators' intellectual property against piracy, which is common in traditional publishing. Adopting blockchain technology will eliminate trust issues because all transactions are timestamped chronologically, and the data is tamper-proof (Estevam et. al, 2021). Additionally, everyone involved in a transaction is informed of its outcome. As a result, every entity within the network has a log of every transaction's specifics, such as the sale, the time, and the amount paid (Ciriello et. al, 2023).

Smart contracts and blockchain technology provide capabilities that can effectively govern how several parties interact, eliminating the need for an intermediary and securing and ensuring creator royalty for each transaction, including a sale (Pei et. al, 2018), (Khan et. al, 2021), (Joshi, et. al, 2024). The envisioned platform provides features to empower music artists, administrators, and stakeholders. Automation, transparency, and obscurity are at the core of the platform's design, offering a user-friendly interface for inputting agreement details, tracking sales, and accessing detailed royalty statements (Kim et. al, 2023). The platform also embraces scalability, security, and performance optimization strategies to guarantee a robust and efficient system.

## 1.2 The challenge of digital piracy

The problem of digital piracy is of a similar kind. The production house is handling asupply chain of digital media products. This piracy can be caught in action by implementing blockchain technology by keeping a trace of the content (asset) owner and ownership transfer. At the same time, the product changes hands through the whole supply chain (Khanna et. al, 2020) Such traceability models have been implemented and evaluated in different use cases, such as fruit (Khanna et. al, 2024) and pharmaceutical drug chains (Bali at. al, 2022) (Uddin et. al, 2021).

In the landscape of the modern digital era, the rapid advancement of technology has ushered in transformative changes across industries, shaping how information and content are produced, distributed, and consumed (Park and Kim, 2024). While this technological progress has opened doors to unprecedented opportunities for content creators, it has also created a complex and pervasive problem: digital piracy. The unauthorized reproduction, distribution, and consumption of copyrighted digital content have emerged as significant challenges, undermining the intellectual property rights of creators, artists, and content producers.

Digital piracy encompasses a wide array of illicit activities involving copyrighted digital content, including but not limited to movies, music, software, e-books, and video games. These acts of piracy manifest in various forms, ranging from illegal downloads and file-sharing platforms to streaming sites that host copyrighted material without proper authorization (Yadav et. al, 2022). This phenomenon poses profound challenges across economic, legal, and ethical domains, impacting the revenue streams of content creators and distributors and the broader content ecosystem and innovation cycle.

One of the most immediate and tangible consequences of digital piracy is its negative impact on the revenue generated by content creators and producers. Unauthorized access to digital content reduces sales and subscriptions, depriving creators of the financial rewards they deserve for their creative efforts. This economic strain can impede their ability to invest in future projects, hampering innovation and ultimately limiting the diversity and quality of content available to consumers.

## 1.3 Organization of the paper

This paper is composed of six sections. Section one introduces the problem faced in music distribution and royalties disbursal and how digital piracy impacts this issue. Thesecond section presents the literature review conducted for the research. The third section presents the methodology of how the decentralized application (DApp) will bedeveloped and deployed. The fourth section presents the system architecture of the suggested solution. Results and discussions of the study have been presented in section five, with conclusions and future scope described in the sixth section.

## 2 LITERATURE REVIEW

According to Sitonio and Nucciarelli, the industry's structure might completely alter due to the introduction of blockchain-powered models. The study of its supply chain models revealed several significant problems, including the ineffectiveness of paying royalties, the need for more transparency throughout the chain, and the poor negotiating power of musicians through programs like metadata analysis, smart contracts, and record keeping. Intermediation may become obsolete, and these problems are resolved.

Smart contracts have recently gained a lot of interest because of their potential to transform many industries completely. The work by Zheng et. al (2020) thoroughly introduces smart contracts, exploring their advancements, problems, and the platforms that facilitate their use. The authors highlight the multifaceted landscape of smart contracts, shedding light on the complexities researchers and practitioners encounter in this dynamic field. The review underscores the challenges inherent in smart contract development and deployment, emphasizing the need for solutions to scalability, security, and interoperability issues.

Several research suggest a comprehensive online copyright administration system built around public blockchains and simulation (Gao et. al, 2024). Copyright holders and users can transact directly through a public chain system, bypassing the need for a central entity. Some research propose an Ethereum-based, robust digitized intellectual property management system (Khan et. al, 2020). These systems also utilize the Inter Planetary File System and smart contract-based paradigm (Peng et. al, 2019). Second, secure privacy and encrypt session data using the enhanced ELGamal encryption method. Assess the improved algorithm's effectiveness. To demonstrate piracy, a transaction watermark that matches the chain's transaction data is also appended to the picture data.

A prototype of the blockchain-based DRM mechanism has been proposed (Zhang and Zhao, 2018). Customers, advertisers, and content creators interact with nodes via blockchain clients. Nodes are responsible for doing fundamental tasks like creating blocks and dealing with smart contracts. The digital content is exclusively for the client's use. The license contains the necessary guidelines and keys. By doing this, fraudulent usage of digital content is prevented (Liang et. al, 2020). Another platform system design is based on blockchain technology by fusing IPFS systems, timestamps, and smart contracts using Hyperledger Fabric, the basis for the system development (Tan et. al, 2021).

Moreover, the paper critically examines the advances made in smart contract technologies. It explores how these self-executing contracts have evolved, incorporating advancements such as enhanced scripting languages, consensus mechanisms, and integration with other emerging technologies. The literature review seeks to provide a thorough overview of cutting-edge smart contract construction by merging these advances.

Wohrer and Zdun (2021) significantly contribute to the understanding and advancement of smart contract development within the Ethereum ecosystem. The identification and categorization of design patterns enrich the academic discourse on blockchain technology and offer practical guidance for developers, fostering the continued evolution and adoption of Ethereum-based smart contracts.

A research offers a valuable synthesis of the current state of security in Ethereum deployed smart contracts (Wang et. al, 2021). It consolidates existing knowledge and charts a course for future investigations, emphasizing the need for ongoing efforts to enhance the security posture of Ethereum-based decentralized applications.

Another research article offers a focused exploration of blockchain technology as a framework for protecting author royalties in the digital realm (Nizamuddin et. al, 2021). It places itself in the larger framework of blockchain applications for rights management, adding to the current conversation about using technology to help content creators deal with the difficulties they confront in the digital world. The research article (Yahya and Habbal, 2021) offers a targeted investigation of blockchain technology's usage in the music business, specifically with regard to royalties. The study adds to the continuing discussion about how blockchain technology may be used in practice to solve enduring problems with copyright and royalty administration in the music industry by putting out a particular payment plan. Additionally, blockchain is beneficial for licensing

involving artists and their creations (Adjovu and Fabian, 2020)
The article (Lovett, 2020) thoroughly analyzes how blockchain technology and digital innovation affect the music business. It does this by drawing on previous research to provide insights into these technologies' revolutionary potential in changing the music ecosystem's dynamics.
A proposed framework produces blocks based exclusively on triggers when the user creates audio assets, reducing blockchain operations. Via hashing, encrypting, decrypting, digital signing, and signature verification, it offers integrity, confidentiality, and nonrepudiation (Kim and Kim, 2020). The technology allows for continuous verification of registered works from any location.
In addition to smart contracts, the IPFS file system (Zheng et. al, 2018) can provide better protection to music creators and their rights, as described in the platform BMCProtector (Zhao and O'Mahony, 2018).

## 3 METHODOLOGY

As explained in this section, the proposed framework may be developed by utilizing a set of technology stacks. The complete methodology is also pictorially represented in Figure 2.

**Blockchain Technology**
Ethereum: The core blockchain technology enabling the creation and execution of smart contracts. Ethereum provides a decentralized platform for rights and royalties management in the music industry.

**Contract Implementation**
Solidity and JavaScript: Programming languages used for writing smart contracts. Solidity is designed explicitly for Ethereum smart contract development, while JavaScript offers flexibility for interacting with the Ethereum blockchain.
Truffle and Hardhat: Development platforms facilitating smart contract development, testing, and deployment. Truffle and Hardhat offer a suite of tools for a streamlined development process.
Mocha and Chai**:** frameworks for testing smart contracts to guarantee their dependability and robustness. Mocha gives a testing framework for thorough and lucid testing, while Chai provides assertion libraries.

**Blockchain Deployment**
Ganache: A platform to create a private, internal Ethereum ledger for development andtest purposes, Ganache allows developers to interact with a simulated Ethereum network, reducing transaction times.
MetaMask: A crypto-wallet accessed through a browser extension. To communicate with the local blockchain generated by Ganache, utilize MetaMask to provide a secureway to manage transactions.

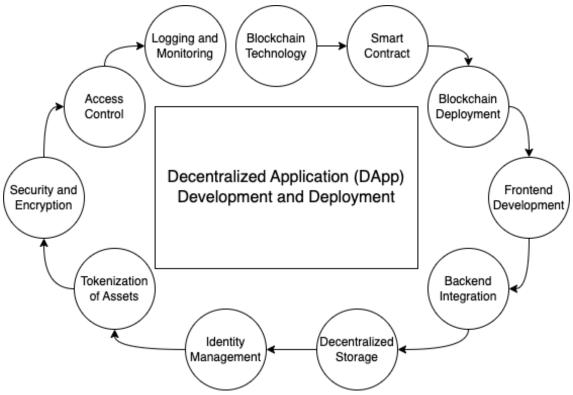


Figure 2: Methodology

**Frontend Development**
React is an open-source JavaScript library for developing the decentralized application's front (DApp). React offers an efficient and modular approach to buildinguser interfaces.

**Backend Integration**
Web3.js: A collection of libraries that facilitates communication between the web application and the Ethereum blockchain. Web3.js enables the implementation of JSON-based Remote Procedure Calls (RPCs) for seamless interaction.

**Decentralized Storage**
IPFS (InterPlanetary File System): A file storage system leveraging Peer-to-Peer (P2P) networking. IPFS is used for storing files, including metadata, in a decentralized and content-based manner.

**Identity Management**
OAuth 2.0 and OpenID Connect: Protocols utilized for secure authorization and authentication processes. OAuth 2.0 ensures secure authorization, while OpenID Connect provides a standardized authentication framework.
Token-based Authentication (e.g., JWT): Mechanisms for secure authentication, using tokens to verify and validate user identity securely.

**Security and Encryption**
HTTPS: Ensures secure data encryption for communication between users and the system, maintaining confidentiality and integrity.
Certificate Pinning: A security measure to ensure that only valid certificates are accepted, enhancing the system's overall security.

**Access Control**
Role-Based Access Control (RBAC): Implemented to manage system permissions and user roles,

guaranteeing that users have the proper access to features based on their roles.

**Logging and Monitoring**

Event Logging: Implemented for critical transactions and system monitoring, providing visibility into system activities.

**Tokenization of Assets**

Token Standard (e.g., ERC-20): The chosen standard for tokenizing assets within the smart contracts. ERC-20 ensures the compatibility and interoperability of tokens.

**Decentralized Application (DApp)**

Integration with IPFS: Seamless integration with IPFS for decentralized storage and retrieval of metadata, enhancing content delivery efficiency.

Pinning Services: Utilized to ensure the availability of specific content on IPFS, even if original contributors go offline.

## 4 SYSTEM ARCHITECTURE

The suggested system design, which focuses on managing rights and royalties in the music industry, incorporates Ethereum blockchain technology for creating and implementing smart contracts. Ethereum facilitates developing and implementing smart contracts, which encode terms and conditions, automate procedures, and carry out transactions according to pre-established logic. The architectural overview can be viewed in Figure 3. The development process involves using languages such as Solidity or JavaScript, with platforms like Truffle and Hardhat for development and Mocha and Chai for testing.

The diagram in Figure 3 shows a smart contract between an artist and a publisher on the Ethereum blockchain. The contract automates selling the artist's work, ensuring that the artist is paid correctly and the publisher receives the work they have paid for.

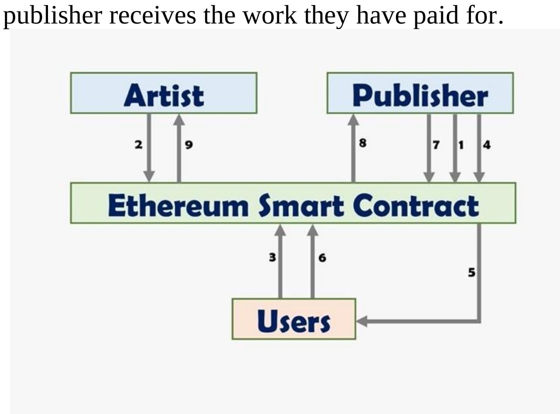


Figure 3: An Architectural Overview

Here are the steps involved in the process:

1. The artist creates the smart contract and specifies the terms of the sale, such as the price of the work and the royalty they will receive.
2. The publisher deposits the amount of money for the work into the smart contract.
3. The artist deposits the work into the smart contract, in the form of a hash (a unique identifier) that proves they own the work.
4. The user deposits the same amount of money as the publisher into the transaction.
5. The executable contract validates that the user has deposited the correct amount of money and that the artist has provided a valid hash.
6. If everything is correct, the work is transferred to the consumer and the payment is disbursed to the artist.
7. The user can then verify the download result.
8. After some time, the smart contract returns the initial deposit and profit to the publisher.
9. The smart contract pays the artist a royalty on every sale of the work.

The smart contract creation includes defining the contract structure, declaring state variables, writing functions, handling access control, and using events for logging. Once a smart contract is created, it undergoes deployment to the Ethereum network through a user-initiated transaction. This process involves creating a transaction that includes the machine code of the smart contract. The transaction is subsequently added to a new block and made available on the blockchain after being verified by Ethereum network miners. The Ethereum blockchain creates a smart contract with a unique address and an Application Binary Interface (ABI) that allows users and other apps to communicate with it.

External interaction with the deployed smart contract is facilitated through users or other smart contracts, which can send transactions to its address. Figure 4 showcases the layered architecture of the model with a network consisting of Polygon or Ethereum nodes. Transaction parameters, such as data or values, can be included depending on the specific method. The smart contract's code contains predefined rules and conditionsfor executing specific methods, leading to automated processes such as calculations, data storage, or interactions with other contracts. State changes, including data storage and emitted events during execution, are recorded on the blockchain, ensuring transparency and immutability.

Ethereum's consensus mechanism, switching from Proof-of-Work to Proof-of-Stake, achieves proper transaction completion. Once a transaction is added in a block and several subsequent blocks are added, the transaction is considered confirmed and irreversible.

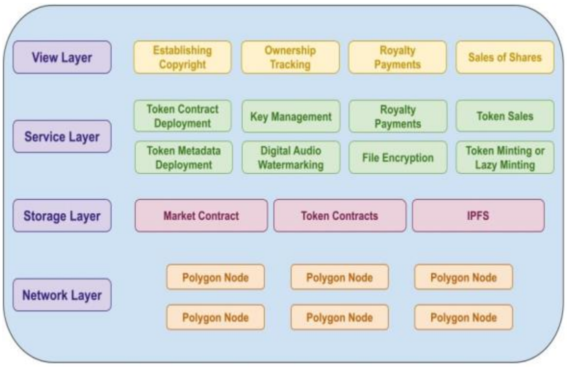


Figure 4: Layered Architecture

Ethereum requires users to pay for computational resources using "gas," with transaction fees compensating miners for the resources used in executing the smart contract.

The proposed system also encompasses the development of smart contracts for managing rights, royalties, and transactions. This involves defining the structure of smart contracts, implementing functions for creating agreements, tracking sales, and distributing royalties, and considering incorporating a token standard (e.g., ERC-20, ERC-721) for asset representation.

Identity management is a crucial architecture component involving implementing a secure system to verify and authenticate users. This includes collecting necessary credentials for user registration, enforcing strong password policies and multifactor authentication, utilizing OAuth 2.0 for secure authorization and OpenID Connect for authentication, implementing token-based authentication mechanisms (e.g., JWT), ensuring secure session management, using HTTPS for data encryption, implementing certificate pinning, incorporating Role-Based Access Control, monitoring critical events, and communicating privacy policies while obtaining user consent for data processing.

The architecture further addresses tokenization of assets, choosing a token standard (ERC-20), implementing a token contract with logic for ownership, transfers, and associated metadata, deciding on metadata storage (on-chain, off-chain, or a combination), minting tokens with considerations for access controls, ensuring transferability, defining metadata URI, integrating with IPFS or other storage solutions, logging events, and developing a decentralized application (DApp) for user interaction.

Figure 5 shows the schematic of the working of IPFS.

Decentralized storage is achieved through IPFS, where files are distributed across a peer-to-peer network. Metadata can be maintained off-chain on IPFS, and the system integrates mechanisms to handle metadata storage and retrieval efficiently. Leveraging IPFS reduces the storage burden on the blockchain, decreasing gas costs for token creation and transfer transactions. The DApp seamlessly integrates IPFS for storage and retrieval of metadata, ensuring efficient content delivery.

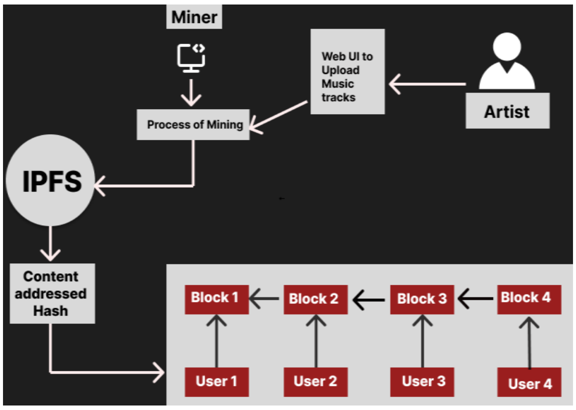


Figure 5: Working of IPFS Storage

Users not running IPFS nodes can still access content through gateways, facilitating broader adoption. Access control mechanisms are considered to manage content updates on IPFS, and pinning services are utilized to ensure the availability of specific content, even if original contributors go offline. Overall, the proposed system architecture provides a comprehensive and secure framework for rights and royalties management in the music industry, leveraging Ethereum, smart contracts, identity management, tokenization, and decentralized storage.

# 5 ROYALTY DISTRIBUTION FUNCTION

In the context of our blockchain-based framework for automatic royalty disbursal, the royalty distribution function is designed to ensure a fair and proportional allocation ofearnings to music artists based on their contributions. The equation (1) represents this function. By leveraging this formula within smart contracts on the blockchain, publishers can automate and transparently manage the disbursal process, ensuring eachartist receives their rightful share based on their relative contribution to the total revenue. This approach not only eliminates the need for intermediaries but also enhances the efficiency, security, and fairness of royalty payments.

The Royalty Distribution function is defined as:

$$Ri = \frac{RXSj}{\Sigma jSj}$$

---- eq. (1)

where:

- $R_i$ is the royalty received by artist $i$.
- $R$ is the total royalty pool available for distribution.
- $S_i$ is the share of the total stake or contribution of artist $i$.
- $\sum_j S_j$ is the sum of shares of all participating artists.

**1. Total Royalty Pool ($R$)**
The total royalty pool $R$ represents the total amount of money available to be distributed among all artists. This could be the revenue generated from streaming services, sales, licensing fees, or other sources.

**2. Artist's Share ($Si$)**
The share $Si$ is a measure of artist $i$'s contribution to the total pool. This can be determined by various metrics such as:

- Number of streams or downloads of the artist's music.
- Percentage of total sales attributed to the artist.
- Specific contractual agreements that define an artist's share.

**3. Sum of Shares ($\sum jSj$)**
The sum of shares $\sum jSj$ represents the total contributions of all artists. It normalizes the individual shares, ensuring that the distribution is proportional to each artist's contribution relative to the total.

1. **Calculate the Total Contribution (Denominator)**
   - First, compute the sum of shares for all artists: $\sum jSj$.
   - This sum represents the total measure of contributions or stakes that artists have in the revenue pool.
2. **Determine the Artist's Proportion (Numerator)**
   - For each artist $i$, calculate their individual share $Si$.

The pseudocode for this function is explained in the results and discussions section.

# 6 RESULTS AND DISCUSSION

The music business can observe encouraging results from adopting the suggested blockchain-based system for managing rights and royalties. Autonomously encoding and executing norms and conditions of agreements can be effectively proved by the smart contracts implemented on the Ethereum network. Each smart contract was assigned a unique address through the deployment process, and its ABI was generated, facilitating seamless external interaction. Transaction finality was ensured by the Ethereum network's consensus mechanism. This confirmed that transactions were included in the blockchain irreversibly.

The identity management system proved effective in ensuring secure user verification and authentication. Implementing robust security measures, including strong password policies, multifactor authentication, and secure session management, contributed to a secure user experience. The use of HTTPS encryption and certificate pinning further enhanced the confidentiality of user data during transmission.

Tokenization of assets using the ERC-20 standard showcased the system's capability to handle fungible assets with efficient logic for ownership, transfers, and metadata management. A snippet of the pseudocode for tokenization and access control is shown in Figure 6. The integration with IPFS for decentralized storage proved to be a pivotal decision, optimizing gas costs associated with on-chain storage and retrieval of metadata. The decentralized application (DApp) successfully provided users a user- friendly interface for interacting with tokens, facilitating actions such as minting, transferring, and viewing metadata.

```
contract DigitalMusicSale {

  // State variables
  address payable artist;
  address payable publisher;
  bytes32 musicHash; // Hash of the artwork
  uint256 price;
  uint256 royalty;
  uint256 startTime; // Timestamp of sale start
  uint256 saleDeadline; // Timestamp of sale end
  uint256 initialDeposit; // Deposit amount required to access
music
  mapping(address => bool) hasPurchased; // Track who has
purchased

  // Modifier to restrict access to specific roles
  modifier onlyArtist() { require(msg.sender == artist); _; }
  modifier onlyPublisher() { require(msg.sender == publisher);}
```

Figure 6: Tokenization and access control pseudocode

Furthermore, the system's decentralized storage component, leveraging IPFS, demonstrated its effectiveness in distributing and storing metadata peer-to-peer. The content addressing mechanism ensured the uniqueness of the content's address (hash) directly linked to the file's content, providing a form of immutability. The musicHash has to be replaced by ipfsHash. The depositMusicHash() function in Figure 7 can be updated to accept and store the artwork's IPFS hash (CID) instead of the music hash itself.

```
// Function for artist to deposit music hash
  function depositMusicHash(bytes32 _musicHash) public
onlyArtist {
    require(block.timestamp < saleDeadline, "Sale deadline has
passed");
     musicHash = _musicHash;
  }

  // Function for publisher to initiate sale
  function initiateSale() public onlyPublisher {
    require(musicHash != 0x0, "Music hash not deposited yet");
  }

  // Function for user to purchase music
  function purchaseMusic() public payable {
    require(msg.value >= initialDeposit, "Insufficient funds");
    require(hasPurchased[msg.sender] == false, "Already
purchased");
    require(block.timestamp < saleDeadline, "Sale deadline has
passed");
```

Figure 7: Artwork sale and purchase pseudocode

This offloading of storage burden from the blockchain significantly reduced gas costs for transactions related to token creation and transfer, contributing to the system's overall efficiency. This research suggests that the proposed blockchain-based system holds substantial promise for addressing the challenges in rights and royalties management within the music industry. The successful deployment of smart contracts, robust identity management, efficient tokenization of assets, and adequate decentralized storage collectively contribute to a comprehensive and innovative solution. Further testing, real-world implementation, and user feedback will be crucial to refining and optimizing the system for broader adoption and industry impact.

For the automatic royalty computation, two key functions—depositing the royalty pool and distributing royalties—are central to the system's operation. These functions ensure that the royalty payments are fairly and transparently allocated to music artists based on their contributions. The depositRoyaltyPool() function, shown in figure 8, allows the contract owner to deposit the total amount of royalties to be distributed among the artists. This amount, known as the total royalty pool ($R$), is collected from various revenue sources such as streaming services, sales, and licensing fees.

```
// Function to deposit the total royalty pool
    function depositRoyaltyPool() public payable onlyOwner {
        require(msg.value > 0, "Royalty pool must be greater than zero");
        totalRoyaltyPool = msg.value;
    }
```

Figure 8: Pseudocode for depositing Royalty Pool

Once deposited, the total royalty pool serves as the basis for the subsequent distribution of royalties. The distributeRoyalties() function as shown in figure 9 calculates each artist's share of the total royalty pool based on their predefined share based on the function defined in eq. (1).

```
    // Function to distribute royalties
    function distributeRoyalties() public onlyOwner {
        require(totalRoyaltyPool > 0, "Royalty pool has not been deposited");
        require(!royaltiesDistributed, "Royalties already distributed");
        uint totalShares = 0; // Variable to store total shares
        for (uint i = 0; i < artists.length; i++) {
            totalShares += artistShares[artists[i]]; // Sum all artist shares
        }
        for (uint i = 0; i < artists.length; i++) {
            address artist = artists[i];
            uint artistShare = artistShares[artist];
            uint royalty = (totalRoyaltyPool * artistShare) / totalShares; //
Calculate individual royalty
            payable(artist).transfer(royalty); // Transfer royalty to artist
        }
        royaltiesDistributed = true; // Mark royalties as distributed
    }
```

Figure 9: Royalty Distribution Function Pseudocode

The depositRoyaltyPool() and distributeRoyalties functions are integral to the automatic and transparent royalty disbursal system. By employing a clear and fair mathematical formula within these smart contract functions, the blockchain framework ensures that each artist receives their rightful share of the total royalties, enhancing trust and efficiency in the royalty distribution process. The provided pseudocode serves as a blueprint for implementing these functions in a Solidity smart contract.

## 7 CONCLUSION

In conclusion, the research comprehensively explores a blockchain-based system designed for rights and royalties management in the music industry. The successful implementation demonstrates the potential for increased transparency, security, and efficiency in managing music-related transactions. Integrating decentralized identity management, tokenization of assets, access control, and decentralized storage using IPFS collectively contribute to a novel and innovative solution for the challenges faced by artists, labels, studios, and other stakeholders in the current centralized music ecosystem.

The proposed blockchain solution for automatic royalty disbursal leverages smart contracts for fair and transparent payments to music artists. To ensure scalability, the system can integrate Layer 2 solutions like state channels and rollups, as well as sharding, to handle high transaction volumes efficiently. Interoperability is achieved through cross-chain communication protocols (e.g., Polkadot, Cosmos) and decentralized oracles (e.g., Chainlink) to integrate with various blockchains and external data sources. For data storage and retrieval, the InterPlanetary File System (IPFS) can be used to manage large datasets like music files and metadata in a decentralized manner. Regulatory compliance is addressed by incorporating KYC (Know Your Customer) mechanisms, auditability features, and privacy-preserving technologies such as zero-knowledge proofs. These technical strategies collectively enhance the feasibility, efficiency, and legal compliance of the blockchain-based royalty distribution system.

There are a number of possible drawbacks to distributing royalties only via cryptocurrency payments. The value of royalties can fluctuate significantly due to market volatility, which makes it challenging for artists to plan financially. Stakeholders without the technical know-how or resources to work with cryptocurrencies may be excluded due to accessibility difficulties. Complying with international regulations and managing cross-border payments can be challenging due to regulatory unpredictability. Excessive transaction costs and network bottlenecks can hinder productivity, while security threats like fraud and hacking necessitate careful precautions. Furthermore, sustainability issues are brought up by the way some blockchain networks affect the environment. Stablecoins and a hybrid payment strategy that combines cryptocurrencies and conventional payment systems might help lessen these disadvantages.

While the results are promising, it is crucial to recognize the ongoing nature of this work. Further refinement and real-world testing are essential to address potential challenges and ensure the practicality and scalability of the proposed system. Engaging with industry stakeholders, regulatory bodies, and end-users will be pivotal in shaping the system to align with industry standards and user expectations. The continuous evolution of blockchain technology, coupled with collaborative efforts within the music industry, holds the potential to usher in a transformative era of fairness, transparency, and efficiency in rights and royalties management.

## REFERENCES


Sharma, R., 2018. Royalty Predicament of the Authors of Musical Works in India: An Exploitative Business. *MIPLC Master Thesis Service*.

Obi, N., 2023. Challenges Relating to the Collection and Distribution of Royalties for Musical Works in Cameroon. *International Journal of Law Policy*. 8, 36–48. https://doi.org/10.47604/ijlp.2083.

Shen, J., 2021. Blockchain Technology and Its Applications in Digital Content Copyright Protection. *In: Yuan, C., Li, X., and Kent, J. (eds.) Proceedings of the 4th International Conference on Economic Management and Green Development.* pp. 18–25. Springer Singapore, Singapore (2021). https://doi.org/10.1007/978-981-16-5359-9_3.

Bali, V., Soni, P., Khanna, T., Gupta, S., Chauhan, S., Gupta, S., 2021. Blockchain Application Design and Algorithms for Traceability in Pharmaceutical Supply Chain. *International Journal of Healthcare Information Systems and Informatics* 16, 1–18. https://doi.org/10.4018/IJHISI.289460.

Oliva, G.A., Hassan, A.E., Jiang, Z.M., 2020. An exploratory study of smart contracts in the Ethereum blockchain platform. *Empirical Software Engineering* 25, 1864–1904. https://doi.org/10.1007/s10664-019-09796-5.

Sitonio, C., Nucciarelli, A., 2018. The Impact of Blockchain on the Music Industry. *Presented at the 29th European Regional Conference of the International Telecommunications Society (ITS): "Towards a Digital Future: Turning Technology into Markets?"* , Trento, Italy.

Estevam, G., Palma, L.M., Silva, L.R., Martina, J.E., Vigil, M., 2021. Accurate and decentralized timestamping using smart contracts on the Ethereum blockchain. *Information Processing and Management* 58, 102471. https://doi.org/10.1016/j.ipm.2020.102471.

Ciriello, R.F., Torbensen, A.C.G., Hansen, M.R.P., Müller-Bloch, C., 2023. Blockchain-based digital rights management systems: Design principles for the music industry. *Electronic Markets* 33, 5 (2023). https://doi.org/10.1007/s12525-023-00628-5.

Pei, X., Sun, L., Li, X., Zheng, K., Wu, X., 2018. Smart Contract Based Multi-Party Computation with Privacy Preserving and Settlement Addressed. *In: 2018 Second World Conference on Smart Trends in Systems, Security and Sustainability (WorldS4)*. pp. 133– 139. IEEE, London. https://doi.org/10.1109/WorldS4.2018.8611588.

Khan, S.N., Loukil, F., Ghedira-Guegan, C., Benkhelifa, E., Bani-Hani, A., 2021. Blockchain smart contracts: Applications, challenges, and future trends. Peer to Peer

Network Applications 14, 2901–2925. https://doi.org/10.1007/s12083-021-01127-0.
Joshi, N., Khanna, T., Bali, V., Bali, S., 2024. NBSOC framework for team structure to develop blockchain-based applications. International Journal of Industrial Systems Engineering 46, 126–149. https://doi.org/10.1504/IJISE.2024.135832.
Kim, Y., Kim, D., Park, S., Kim, Y., Hong, J., Hong, S., Jeong, J., Lee, B., Oh, H., 2023 A Proposed Settlement and Distribution Structure for Music Royalties in Korea and Their Artificial Intelligence-Based Applications. *Applied Sciences* 13, 11109 (2023). https://doi.org/10.3390/app131911109.
Khanna, T., Nand, P., Bali, V., 2020 Permissioned Blockchain Model for End-to-End Trackability in Supply Chain Management. *International Journal of E-Collaboration* 16, 45–58 (2020). https://doi.org/10.4018/IJeC.2020010104.
Khanna, T., Nand, P., Bali, V., 2024 FruitBlock: a layered approach to implement blockchain- based traceability system for agri-supply chain. *International Journal of Business Information Systems* 43, 107. https://doi.org/10.1504/IJBIS.2023.131088.
Bali, V., Khanna, T., Soni, P., Gupta, S., Chauhan, S., Gupta, S., 2022. Combating Drug Counterfeiting by Tracing Ownership Transfer Using Blockchain Technology. *International Journal of E- Health Medical Communications* 13, 1–21. https://doi.org/10.4018/IJEHMC.309429.
Uddin, M., 2021. Blockchain Medledger: Hyperledger fabric enabled drug traceability system for counterfeit drugs in pharmaceutical industry. International Journal of Pharmacy 597, 120235. https://doi.org/10.1016/j.ijpharm.2021.120235.
Park, Y., Kim, S., 2024. Do artists perceive blockchain as a new revenue opportunity? A social representation study of the Korean music industry. Humanities and Social Sciences Communication 11, 161. https://doi.org/10.1057/s41599-024-02657-7.
Yadav, J., Misra, M., Singh, K., Goundar, S., 2022 Unmasking Counterfeit Readymade Garments in India Using Blockchain Technology. *In: The Convergence of Artificial Intelligence and Blockchain Technologies.* pp. 393–410. WORLD SCIENTIFIC. https://doi.org/10.1142/9789811225079_0018.
Zheng, Z., Xie, S., Dai, H.-N., Chen, W., Chen, X., Weng, J., Imran, M., 2020. An overview on smart contracts: Challenges, advances and platforms. *Future Generation Computer Systems* 105, 475–491. https://doi.org/10.1016/j.future.2019.12.019.
Gao, Y., Wen, J., Miao, P., Wang, Z., 2024. Digital Copyright Transaction Scheme Based on Blockchain Technology. *In: Zhang, Y., Qi, L., Liu, Q., Yin, G., and Liu, X. (eds.) Proceedings of the 13th International Conference on Computer Engineering and Networks.* pp. 130–139. Springer Nature Singapore, Singapore. https://doi.org/10.1007/978-981-99-9247-8_13.
Khan, U., An, Z.Y., Imran, A., 2020. A Blockchain Ethereum Technology-Enabled Digital Content. Development of Trading and Sharing Economy Data. *IEEE Access*. 8, 217045– 217056. https://doi.org/10.1109/ACCESS.2020.3041317.
Peng, W., Yi, L., Fang, L., XinHua, D., Ping, C., 2019. Secure and Traceable Copyright Management System Based on Blockchain. *In: 2019 IEEE 5th International Conference on Computer and Communications (ICCC)*. pp. 1243–1247. IEEE, Chengdu, China (2019). https://doi.org/10.1109/ICCC47050.2019.9064101.
Zhang, Z., Zhao, L., 2018. A Design of Digital Rights Management Mechanism Based on Blockchain Technology. *In: Chen, S., Wang, H., and Zhang, L.-J. (eds.) Blockchain – ICBC 2018*. pp. 32–46. Springer International Publishing, Cham. https://doi.org/10.1007/978-3-319-94478-4_3.
Liang, W., Lei, X., Li, K.-C., Fan, Y., Cai, J., 2020. A Dual-Chain Digital Copyright Registration and Transaction System Based on Blockchain Technology. *In: Zheng, Z., Dai, H.-N., Tang, M., and Chen, X. (eds.) Blockchain and Trustworthy Systems.* pp. 702– 714. Springer Singapore, Singapore. https://doi.org/10.1007/978-981-15-2777- 7_57.
Tan, W., Zhang, X., Cai, X., 2021. Digital Rights Management Platform Based on Blockchain Technology. *In: Zu, Q., Tang, Y., and Mladenović, V. (eds.) Human Centered Computing.* pp. 173–183. Springer International Publishing, Cham. https://doi.org/10.1007/978-3-030-70626-5_18.
Wohrer, M., Zdun, U., 2018. Design Patterns for Smart Contracts in the Ethereum Ecosystem. *In: 2018 IEEE International Conference on Internet of Things (iThings) and IEEE Green Computing and Communications (GreenCom) and IEEE Cyber, Physical and Social Computing (CPSCom) and IEEE Smart Data (SmartData).* pp. 1513–1520. IEEE, Halifax, NS, Canada. https://doi.org/10.1109/Cybermatics_2018.2018.0025.
Wang, Z., Jin, H., Dai, W., Choo, K.-K.R., Zou, D., 2021. Ethereum smart contract security research: survey and future research opportunities. Front. Comput. Sci. 15, 152802. https://doi.org/10.1007/s11704-020-9284-9.
Nizamuddin, N., Hasan, H., Salah, K., Iqbal, R., 2019. Blockchain-Based Framework for Protecting Author Royalty of Digital Assets. Arabian Journal of Science and Engineering 44, 3849–3866. https://doi.org/10.1007/s13369-018-03715-4.
Yahya, A., Habbal, A., 2021. Music Royalty Payment Scheme Using Blockchain Technology. *In: 2021 5th International Symposium on Multidisciplinary Studies and Innovative Technologies (ISMSIT).* pp. 539–545. IEEE, Ankara, Turkey. https://doi.org/10.1109/ISMSIT52890.2021.9604559.
Adjovu, C., Fabian, E., 2020. Blockchain-mediated Licensing: Legal Engineering for Artist Empowerment. *SSRN Electronic Journal.* https://doi.org/10.2139/ssrn.3625317.
Lovett, M., 2020. Directions in Music: Stakeholder Perspectives on Blockchain Innovations in Music Streaming. *Frontiers in Blockchain.* 3, 506721. https://doi.org/10.3389/fbloc.2020.506721.

Kim, A., Kim, M., 2020. A Study on Blockchain-based Music Distribution Framework: Focusing on Copyright Protection. *In: 2020 International Conference on Information and Communication Technology Convergence (ICTC)*. pp. 1921–1925. IEEE, Jeju, Korea (South). https://doi.org/10.1109/ICTC49870.2020.9289184.

Zheng, Q., Li, Y., Chen, P., Dong, X., 2018. An Innovative IPFS-Based Storage Model for Blockchain. *In: 2018 IEEE/WIC/ACM International Conference on Web Intelligence (WI)*. pp. 704–708. IEEE, Santiago (2018). https://doi.org/10.1109/WI.2018.000-8.

Zhao, S., O'Mahony, D., 2018. BMCProtector: A Blockchain and Smart Contract Based Application for Music Copyright Protection. *In: Proceedings of the 2018 International Conference on Blockchain Technology and Application.* pp. 1–5. ACM, Xi'an China. https://doi.org/10.1145/3301403.3301404.