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Blockchain for Digital Rights Management (DRM) in the Entertainment Industry and Emerging Metaverse Ecosystems

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Abstract

This research examines how blockchain technology can address long-standing challenges in digital rights management (DRM) within the entertainment industry and emerging Metaverse environments. By leveraging decentralized ledgers and smart contracts, blockchain offers immutable ownership records, automated royalty payments, and robust piracy prevention mechanisms. These features can substantially enhance transparency, reduce reliance on intermediaries, and streamline complex licensing processes. However, widespread adoption requires overcoming several obstacles, including network scalability limitations, user experience shortcoming, and uncertain legal frameworks across different jurisdictions. The study identifies potential solutions such as layer-2 scaling options, user-friendly platforms for content creators, and the development of uniform industry standards. Regulatory clarity and cooperative efforts among technologists, policymakers, and rights holders are also highlighted as essential factors in facilitating a more equitable and secure environment for digital content distribution. If effectively implemented, blockchain-based DRM could redefine how creators maintain control and monetize their intellectual property, ushering in a new era of efficiency, security, and transparency in both the entertainment sector and the Metaverse.

Keywords: Blockchain, Digital Rights Management (DRM), Smart Contracts, Tokenization, Entertainment Industry, Piracy Prevention, Content Distribution, Metaverse, Current DRM Landscape and Ongoing Challenges.

Introduction

The entertainment industry—encompassing music, film, publishing, and gaming—plays a pivotal role in the global economy yet continues to face significant challenges in the realm of digital rights management (DRM) [1]. As consumers increasingly access content through digital channels, issues such as unauthorized sharing, piracy, and convoluted licensing agreements have led to substantial revenue losses for creators and heightened legal complexities for distributors [2].

Moreover, the emergence of new digital environments such as the Metaverse is expanding the landscape of content creation and distribution, introducing fresh challenges and opportunities for digital rights management. Conventional DRM systems, often centralized and reliant on proprietary technologies, have proven vulnerable to hacking, content leaks, and a lack of trans-

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parent royalty distribution [3].

In response to these growing concerns, blockchain technology— first popularized by its application in cryptocurrencies—has emerged as a promising solution to reimagine DRM in a more secure, transparent, and efficient manner [2]. At its core, blockchain functions as a decentralized, tamper-evident ledger that can record transactions and ownership changes without relying on a single controlling entity [1]. This makes technology highly resilient to manipulation, providing a reliable infrastructure for tracking the creation, distribution, and use of digital content [4]. In particular, smart contracts—self-executing code deployed on the blockchain—offer the potential to automate licensing terms, instantly distribute royalties, and enforce compliance with usage rights [5].

Furthermore, by tokenizing digital assets (e.g., music files, film footage, or e-books) on a blockchain, stakeholders can maintain immutable records of ownership and trace every transaction or transfer of rights, thereby reducing the scope for unauthorized duplication [3]. This represents a major shift from traditional DRM frameworks, as it introduces the concept of digital scarcity and allows creators to retain granular control over how their work is accessed or monetized [2]. Despite these advantages, challenges persist in implementing blockchain-based DRM on a scale, including high transaction fees on certain networks, a steep learning curve for content creators, and the absence of universal legal frameworks to govern smart contracts [1].

The primary goal of this research is to investigate how blockchain can secure copyrights and prevent unauthorized use of digital content in the entertainment industry. By examining the core components of blockchain-enabled DRM—namely, smart contracts, digital ownership, and piracy prevention—this study aims to highlight both the potential benefits and the practical obstacles to widespread adoption.

Blockchain technology offers transformative solutions for Digital Rights Management (DRM) in the entertainment industry by addressing critical areas such as smart contracts, digital ownership, and piracy prevention. Smart contracts enable the automation of license agreements, royalty payments, and content access rules, reducing reliance on intermediaries and ensuring real-time transactions. Digital ownership is reinforced through blockchain's immutable ledger, providing verifiable records of creation and transfers of digital assets, ensuring transparency and rightful attribution. Additionally, piracy prevention is enhanced as blockchain's traceability mechanisms help track unauthorized content distribution, discouraging illicit sharing and ensuring compliance. However, several challenges must be addressed before widespread adoption. Scalability remains a major hurdle, as high network fees and congestion on popular blockchains like Ethereum can limit real-time DRM applications.

Adoption barriers also pose challenges, as many content creators face technical hurdles, usability issues, and resistance from established industry players who may be reluctant to transition from centralized models. Addressing these challenges through scalable blockchain solutions, improved user interfaces, and industry-wide collaborations will be crucial for the successful implementation of blockchain-based DRM systems. By analyzing these aspects in detail, this research will provide insights into how the entertainment industry might harness blockchain's decentralized architecture to create a more equitable, transparent, and secure ecosystem for digital rights management.

Background and Current DRM Landscape

Traditional methods of Digital Rights Management (DRM) typically rely on centralized servers and proprietary software to grant or deny access to digital content [2]. In these systems, a central authority—such as a streaming platform or publisher—manages user authentication

and license validation through encryption keys or access tokens. While this approach provides a degree of protection by restricting unauthorized copying, it remains vulnerable to reverse engineering and hacking [3]. Once the protective layer is bypassed, the content can be duplicated and redistributed widely, undermining creators' ability to monetize their work [1]. In addition to security weaknesses, centralized DRM architecture creates significant administrative overhead and lack transparency [4]. Content creators often deal with multiple intermediaries, from record labels to digital distributors, each of which has its own licensing framework. This fragmentation leads to delayed royalty payments, inconsistent data management, and frequent disputes over revenue shares [6]. For example, a single music track might be played across different streaming services and in various geographic regions, each governed by separate licensing agreements—an arrangement that complicates the accurate tracking and timely distribution of royalties [2].

The Limitations of Centralized DRM

Centralized DRM models place considerable trust in a few key entities to maintain secure and honest operations [3]. However, high-profile breaches illustrate that no single repository is immune to cyberattacks, and once compromised, attackers can manipulate or remove DRM controls at scale [1]. Furthermore, because creators rarely have real-time visibility into how their content is used or monetized, disputes over licensing terms and royalty calculations are common [4].

Comparison of Traditional vs. Blockchain-Based DRM Traditional DRM systems operate under centralized authority, leading to delayed royalty distributions and limited transparency. By contrast, blockchain-based DRM leverages decentralized ledgers and smart contracts to address some of these longstanding inefficiencies. Table 1 provides a side-by-side analysis of the functional differences between these two approaches.

Table 1: Comparison of Traditional DRM VS. Blockchain-Based DRM

Feature/Metric	Traditional DRM	Blockchain-based DRM
Control Mechanism	Centralized authority (Mougayar, 2016)	Decentralized ledger (Tapscott & Tapscott, 2016)
Royalty Distribution Speed	Delayed (monthly/quarterly) (Kshetri, 2017)	Near real-time via smart contracts (Casey & Vigna, 2018)
Transparency	Low (opaque processes) (Pilkington, 2016)	High (immutable ledger) (Mougayar, 2016)
Piracy Prevention	Moderately effective (Tapscott & Tapscott, 2016)	Potentially more secure (traceability) (De Filippi & Wright, 2018)
Transaction Fees	Platform-dependent (Mougayar, 2016)	Blockchain network fees (varying by protocol) (Valenta & Sandner, 2017)
Scalability	High with centralized servers (Pilkington, 2016)	Dependent on network throughput (Zamyatin et al., 2021)
Adoption	Well-established, widely used (Tapscott & Tapscott, 2016)	Emerging, growing adoption (Bodkhe et al., 2020)

Following this comparison, it becomes evident that blockchain can introduce more efficient

revenue streams for creators while strengthening security measures against piracy. Nonetheless, blockchain-based DRM must overcome challenges such as network congestion, high transaction fees, and legal uncertainties before it can fully supplant traditional methods. The next sections will explore how these limitations can be addressed and how different segments of the entertainment industry are beginning to embrace or experiment with blockchain solutions.

Blockchain's Potential Role

Blockchain technology introduces a Decentralized Ledger mechanism that could address several of these challenges by distributing the validation process across many network nodes, thereby reducing reliance on a central authority [5]. Rather than storing rights management data on a single server, each transaction—such as content creation, transfer of ownership, or licensing—gets recorded across the blockchain in an immutable manner [1]. This structure ensures transparency and traceability, making it more difficult for unauthorized users to alter records or bypass protections [7].

a. Immutable Ownership Records: Each piece of digital content (e.g., a song, film, or e-book) can be “tokenized,” creating a unique cryptographic representation of that content on the blockchain. Additionally, the rise of non-fungible tokens (NFTs) has further expanded the concept of tokenization, allowing unique digital assets—such as virtual goods in the Metaverse—to be securely authenticated, owned, and traded across decentralized platforms. This token can store metadata about the asset’s creator and its ownership history [2].

Automated Licensing Through Smart Contracts: Smart contracts on the blockchain can enclose specific rules such as play limits, time-bound access, or geographic restrictions—and enforce them automatically once certain conditions are met [3]. When a user attempts to access content, the smart contract checks the predefined terms; if satisfied, it grants access and triggers the appropriate royalty distribution [6].

b. Fraud Detection and Piracy Prevention: Because every transaction is recorded, any unauthorized copying or sharing of assets can be traced back to the account that initially breached the terms [5]. This “trustless” environment incentivizes honest behavior, as all nodes in the network can verify and audit the chain of custody for digital assets [7].

Ongoing Challenges

While blockchain offers a novel framework for DRM, practical barriers still hinder widespread adoption [1]. Scalability is a primary concern—popular blockchain networks can experience high transaction fees and slow throughput, limiting their applicability for high-volume content distribution [2]. Additionally, User Experience remains a stumbling block, as setting up digital wallets and managing private keys can be daunting for content creators with limited technical backgrounds [6]. Lastly, legal uncertainties persist; smart contracts operate in a borderless, decentralized environment, yet intellectual property laws vary across jurisdictions, complicating enforcement [3]. Despite these issues, blockchain’s core attributes—decentralization, immutability, and programmability, it is a potentially transformative tool for DRM. By offering transparency in rights management and a secure channel for content distribution, blockchain-based DRM solutions could reshape the entertainment industry’s approach to licensing and monetization [7].

How Blockchain Can Enhance DRM

Smart Contracts for Licensing and Royalty Payments

Figure 1 uncovers revenue distribution in a blockchain-based DRM system vs. a traditional DRM model. By automating royalty splits via smart contracts, creators receive a significantly higher percentage of total revenue, reducing the need for intermediaries and excessive

platform fees [5, 3].

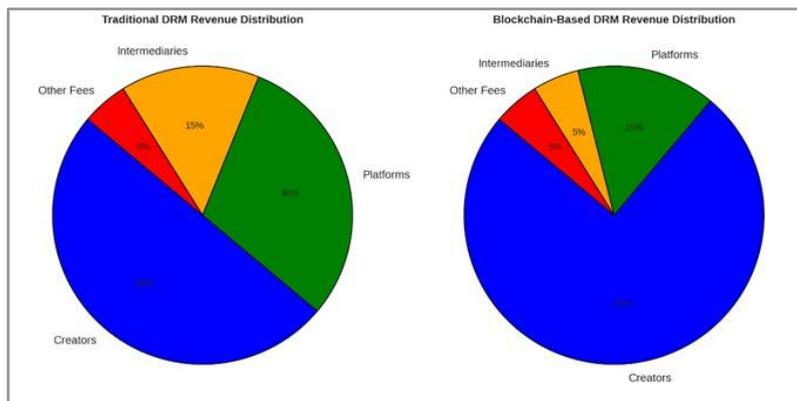


Figure 1: Traditional DRM VS. Blockchain-Based DRM Revenue Distribution

a. Automated Licensing: Smart contracts can encode usage terms (e.g., geographical restrictions, number of plays, time windows) and automatically execute license agreements once conditions are met [8, 9]. This reduces the need for manual intervention and complex legal agreements, providing a more efficient way to control content distribution.

b. Real-Time Royalty Distribution: Traditional royalty systems often involve delayed and opaque payment processes [2]. By contrast, smart contracts can instantly distribute royalties to stakeholders as soon as a sale or stream occurs, improving transparency and payment speed [10, 1].

Digital Ownership and Asset Tokenization

a. Immutable Ownership Records: A blockchain ledger can store a perpetual, transparent record of who owns a piece of digital content [6]. This includes both initial ownership (creator) and subsequent transactions (transfers or sales), reducing the likelihood of ownership disputes [8].

b. Tokenized Assets: Music tracks, films, and e-books can be tokenized, enabling creators to sell fractional ownership or rights [9, 7]. For instance, a musician might sell a percentage of their streaming royalties to early supporters, providing a new revenue model and direct fan engagement [2].

Piracy Prevention and Secure Distribution

a. Encrypted Content and Access Control: Blockchain-based DRM platforms often integrate secure encryption and token-based access [3]. Only those holding valid tokens or keys can decrypt and consume the content, significantly reducing unauthorized usage [10].

b. Traceability: Because every transaction or content access can be logged on the blockchain, unauthorized sharing is easier to detect [5]. If a piece of content is leaked, the platform can trace which account distributed it, discouraging piracy and holding violators accountable [6].

Use Cases and Industry Adoption

Music Streaming Platforms

Platforms such as Audius leverage blockchain to reward artists directly, reducing intermediaries, and ensuring transparent royalty tracking [11]. By eliminating traditional gatekeepers (e.g., record labels, music publishers, and streaming services), blockchain-based platforms allow musicians to upload and monetize their work in a peer-to-peer manner. This

model not only provides greater financial returns for artists but also increases the transparency and speed of royalty payments [2].

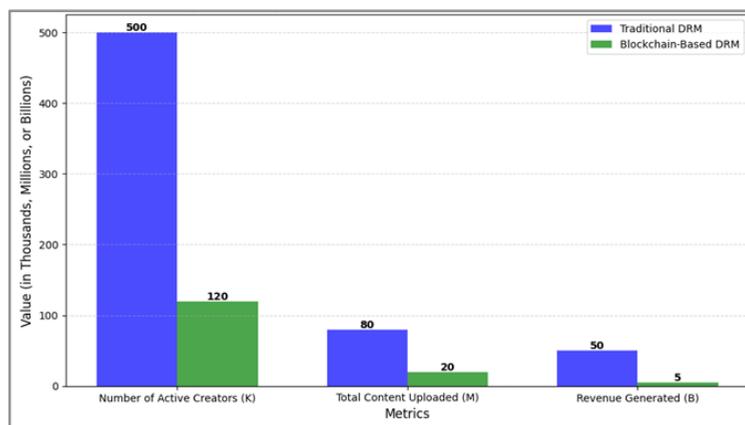


Figure 2: Adoption Rates of Blockchain-Based DRM VS. Traditional DRM, 2024

Traditional DRM has a significantly higher adoption rate, with 500,000 active creators. Blockchain-based DRM is growing but remains smaller, with 120,000 active creators. Blockchain adoption is steadily increasing, but technical, legal, and market barriers must be addressed. Figure 2. Adoption rates for blockchain-based DRM platforms compared to traditional DRM platforms over the last 2 years. Data suggests steady, albeit smaller, growth for decentralized models, with potential for acceleration if technical and legal hurdles are mitigated [11, 2].

Film and Video-On-Demand Services

Decentralized video-on-demand (VOD) platforms are emerging to allow filmmakers, especially independent creators, to upload their content and receive payments from viewers directly via smart contracts [12]. In this setup, content access can be sold or rented out on a blockchain ledger, with each viewer transaction automatically triggering royalty payments. Such a system can minimize the dominance of large studios and distributors, giving indie filmmakers greater autonomy over the distribution process [5].

Publishing and E-Books

By tokenizing e-books, authors and publishers can track each instance of purchase, borrowing, or resale in near-real time [13]. This approach mitigates the risk of unauthorized duplication and helps ensure that creators receive fair compensation. Direct peer-to-peer sales can also bypass traditional retailers, thereby reducing fees and facilitating more transparent revenue shares [6].

Gaming and Virtual Goods

Blockchain-based games incorporate non-fungible tokens (NFTs) to represent in-game items, giving players verifiable digital ownership (Li, 2021). Unlike traditional gaming ecosystems—where assets often exist solely within the confines of a developer’s platform, NFTs can be traded freely on external marketplaces, eliminating counterfeit items [7]. This interoperability not only enhances player engagement but also creates new revenue streams for developers and user communities [3].

DRM in the Metaverse

In parallel with developments in traditional entertainment sectors, the Metaverse has emerged as a rapidly evolving digital ecosystem where issues of ownership, access, and distribution take on new dimensions. As virtual worlds become increasingly important sites for cultural production and economic exchange, effective Digital Rights Management (DRM) frameworks are essential to safeguard creators' intellectual property and maintain trust in decentralized environments. The emergence of the Metaverse—a collective, persistent, and immersive digital environment—presents both unprecedented opportunities and unique challenges for Digital Rights Management (DRM). As users create, share, and monetize digital assets such as virtual real estate, avatars, music performances, art exhibitions, and gaming experiences within Metaverse platforms, securing ownership rights becomes even more critical. Blockchain technology underpins many Metaverse ecosystems by providing decentralized infrastructure for asset tokenization and transaction verification (Li, 2021). Non-fungible tokens (NFTs), built on blockchain protocols, enable the representation of unique digital items, ensuring provenance and verifiable ownership across virtual worlds.

Key DRM implications in the Metaverse include:

a. Ownership Authentication: Blockchain's immutable ledgers can verify the origin, authenticity, and ownership history of virtual goods, reducing risks of counterfeiting and unauthorized duplication [8].

b. Automated Licensing: Smart contracts can facilitate rental, resale, or licensing of virtual assets (e.g., leasing a digital store in a virtual mall), ensuring automatic royalty payments and compliance enforcement [10].

c. Cross-Platform Interoperability: Effective DRM in the Metaverse requires interoperability across different virtual worlds. Blockchain standards can help synchronize asset rights, allowing users to move virtual goods between ecosystems without losing provenance or rights [7].

However, the Metaverse also introduces new challenges, such as jurisdictional ambiguity over digital property rights, evolving legal frameworks for virtual transactions, and scalability issues for managing millions of microtransactions in real time. Integrating blockchain-based DRM into Metaverse environments can enable creators to safeguard intellectual property, foster new monetization models, and promote fair exchanges in decentralized digital economies.

Challenges in Blockchain-Based DRM

High fees on Ethereum during congestion (Days 3–5) could impede real-time DRM applications, where numerous small-value transactions are required. By contrast, Polygon and Solana maintain lower fees that may be more conducive to frequent microtransactions and automated royalty settlements [10, 2]. Figure 3 depicts the fluctuation in average transaction fees for three major blockchains over seven days. This variability highlights how sudden fee spikes—particularly on Ethereum—can undermine the economic viability of frequent on-chain DRM transactions [14]. As a result, alternative or Layer-2 solutions like Polygon may be better suited for high-volume digital content licensing, where cost predictability is essential [15].

Scalability

High Network Fees and Latency: Popular blockchains such as Ethereum often experience congestion, leading to elevated transaction fees and slower processing times [10, 14]. These performance bottlenecks can impede real-time DRM applications, particularly for high-volume content platforms that require instantaneous licensing or payment settlements [2].

Layer-2 Solutions and Alternative Blockchains: To address performance concerns, new

architectures like sidechains, rollups, or dedicated high-throughput blockchains (e.g., Solana, Polygon) have emerged [15]. While these solutions can reduce fees and latency, migrating to or adopting newer blockchains can fragment the ecosystem and introduce interoperability challenges [8].

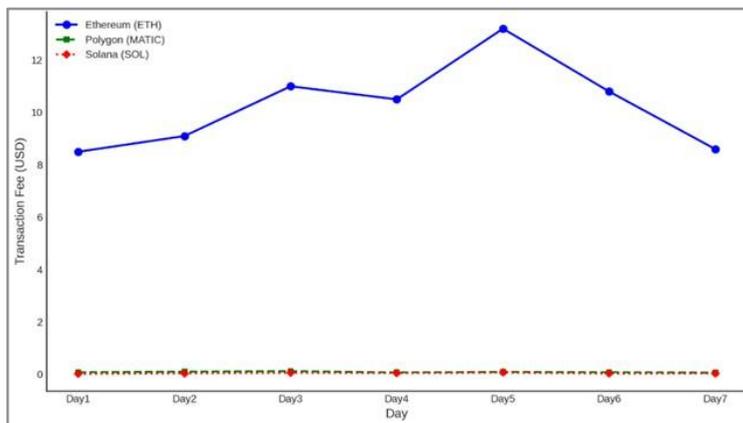


Figure 3: Average Transaction Fees (USD) for ETH, Matic, and SOL Over 7 Days

Evaluating Blockchain Platforms for DRM

Scalability remains a core challenge in implementing blockchain-based DRM, particularly for large-scale content distribution. High transaction fees and latency can disrupt real-time licensing, while limited throughput constrains the number of concurrent user interactions. Table 2 provides an overview of several popular blockchain ecosystems and Layer-2 solutions, comparing their throughput, fee structures, consensus mechanisms, and typical use cases. This comparison helps stakeholders assess which platform might be most suitable for integrating DRM functionalities based on performance and cost requirements.

Table 2: Blockchain Platforms and their Key Metrics

Blockchain / Layer-2	Transaction Throughput (TPS)	Average Fee	Consensus Mechanism	Notable Use Cases
Ethereum	~15–30 (Valenta & Sandner, 2017)	High (variable) (Christidis & Devetsikiotis, 2016)	Proof of Stake (Pilkington, 2016)	NFT marketplaces, DeFi (Tapscott & Tapscott, 2016)
Polygon (Layer-2)	~65,000+ (Zamyatin et al., 2021)	Low (Bodkhe et al., 2020)	PoS sidechain (Valenta & Sandner, 2017)	Gaming, microtransactions (Mougayar, 2016)
Solana	~2,000+ (theoretical) ~50,000 (Zamyatin et al., 2021)	Low (Bodkhe et al., 2020)	Proof of History (Pilkington, 2016)	High-volume trading, NFTs (Casey & Vigna, 2018)
BNB Chain	~300 (Christidis & Devetsikiotis, 2016)	Moderate (Tapscott & Tapscott, 2016)	Proof of Staked Authority (Valenta & Sandner, 2017)	DeFi, token launches (Mougayar, 2016)

Others (e.g., Avalanche)	~4,500+ (Bodkhe et al., 2020)	Moderate (Pilkington, 2016)	Proof of Stake (Zamyatin et al., 2021)	Asset tokenization, NFTs (De Filippi & Wright, 2018)
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Although Ethereum remains popular for its robust developer community and mature ecosystem, its high fees and moderate throughput can pose obstacles for content creators requiring near-instant transactions. Layer-2 solutions and alternative blockchains, such as Polygon or Solana, offer faster and cheaper transactions but may have different security models or interoperability considerations. Deciding on a suitable platform thus depends on a variety of factors, including user volume, budget constraints, and desired levels of decentralization. By understanding these core metrics, stakeholders can more effectively plan for the technical and economic implications of integrating blockchain into DRM workflows.

Royalty Distribution Lifecycle in a Blockchain-Based DRM System

A key advantage of integrating blockchain into digital rights management is the ability to automate and streamline royalty flows [2, 1]. This process—ranging from the initial tokenization of content to final payments to rights holders—can be broken down into distinct stages, each harnessing smart contract capabilities or other blockchain features [3]. Table 3 below provides a concise overview of this lifecycle, illustrating where and how blockchain adds value at each step.

Table 3: Royalty Distribution Lifecycle in a Blockchain-Based DRM System

Stage	Action	Technology Involved
Content Tokenization	Convert media into blockchain tokens	Smart contract
Usage Tracking	Log content consumption events	Distributed ledger
Royalty Calculation	Automatic calculation based on usage data	Smart contract logic
Payment Execution	Trigger instant payment to rightsholders	Native token (e.g., ETH)
Record Update	Update ledger with payment details	Blockchain network

In traditional scenarios, usage metrics are collected by third-party platforms, and royalties can be disbursed months later, often leading to disputes or lack of transparency [6]. By contrast, blockchain-based DRM centralizes usage data within an immutable ledger, enabling near-instant royalty disbursements to all relevant parties [8]. This lifecycle ensures that every stage—from the creation of digital content to the final payment—is consistently recorded on the blockchain, reducing administrative overhead and improving trust among stakeholders [10]. Moreover, because each transaction is verifiable, content creators can audit royalty flows in real time, fostering a more equitable ecosystem [5]. Figure 4. Flowchart illustrates the royalty distribution lifecycle in a blockchain-based DRM system, from content tokenization to final royalty payout. Each step is recorded on a transparent, immutable ledger, reducing administrative costs and preventing royalty disputes [1, 8].

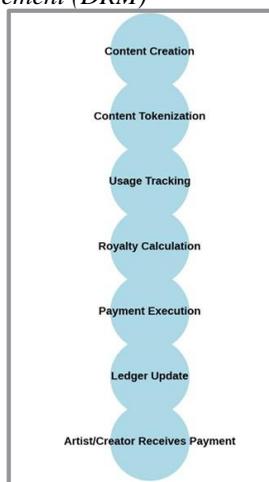


Figure 4: Blockchain-Based Royalty Distribution Lifecycle

Adoption Barriers among Content Creators

Lack of Technical Knowledge: Many creators are unfamiliar with blockchain technology, struggling to tokenize their work or deploy smart contracts without specialized support [6]. This skills gap can lead to missed opportunities for direct monetization and deeper audience engagement [11].

Complex User Experience (UX): The requirement to set up digital wallets and manage private keys remains a significant hurdle for non-technical users [3]. Platforms that seek to drive widespread adoption must streamline onboarding processes and offer user-friendly interfaces, lowering the barrier to entry [1].

Resistance to Change: Established publishers, record labels, and studios have entrenched business models and revenue structures. They may be hesitant to embrace decentralized approaches if they fear a loss of control over distribution or diminished profit margins [2].

Regulatory and Legal Hurdles

Jurisdictional Differences: Copyright and intellectual property laws vary significantly across regions, creating ambiguity about how blockchain-based records interact with local legal frameworks. This inconsistency can hinder cross-border enforcement of smart contract terms [8].

Smart Contract Legality: Although certain jurisdictions are beginning to recognize smart contracts as legally binding, many lack clear regulations, leading to concerns about enforceability, especially in international contexts [10]. These legal uncertainties can deter major industry players from fully committing to decentralized DRM solutions [6].

Potential Solutions and Recommendations

Education and Awareness Campaigns

Content creators and rights holders must be educated on the practical benefits and nuances of blockchain-based DRM. Workshops, online courses, and simplified technical documentation can significantly reduce the learning curve [6]. By highlighting successful case studies and demonstrating tangible benefits—such as faster royalty payments and enhanced copyright protection, educators can help demystify the technology for non-technical stakeholders [3].

User-Friendly Platforms and Wallets

A major barrier to adoption is the complexity of setting up digital wallets and managing private keys [1]. To drive broader acceptance, blockchain platforms should prioritize one-click token minting, intuitive licensing templates, and secure yet streamlined key management solutions [2]. Implementing clear user interfaces and robust customer support can empower creators who lack deep technical expertise, encouraging them to explore tokenizing their work and deploying smart contracts [10].

Scalable Blockchain Infrastructures

Many blockchain networks face congestion and high transaction fees, which can hinder real-time DRM use cases [14]. Adopting layer-2 solutions (e.g., sidechains, rollups) or alternative high-throughput blockchains (e.g., Solana, Polygon) can help reduce costs and improve speed [15]. Additionally, hybrid models that combine public blockchains with private or consortium chains may offer a balance of security, efficiency, and ease of governance [1].

Standards and Interoperability

The entertainment industry would benefit from agreed-upon standards for digital asset representation, licensing terms, and data interchange formats [11]. Establishing interoperable protocols reduces fragmentation across different platforms and networks, enabling content creators to easily move their digital assets between marketplaces [2]. Over time, consistent standards can foster a more unified and efficient ecosystem for DRM solutions [7].

Legal Clarifications and Frameworks

Uncertainty around how smart contracts fit within existing legal frameworks remains a critical hurdle [8]. Policymakers and industry bodies should collaborate to develop clear guidelines on the enforceability of smart contracts and address cross-border intellectual property (IP) issues [6]. Such clarity would help major industry players—record labels, film studios, and publishing houses—adopt blockchain-based DRM with greater confidence [5].

Conclusions

Blockchain offers a transformative approach to digital rights management by decentralizing control, increasing transparency, and enabling automated, real-time royalty payments through smart contracts. By tokenizing content assets and recording transactions on an immutable ledger, this technology can reduce piracy and simplify complex licensing processes, fostering a more equitable environment for creators [16]. Nonetheless, the path to widespread adoption is not without hurdles – scalability issues, user onboarding challenges, and legal uncertainties must be addressed to unlock the full potential of blockchain-based DRM. As digital content consumption continues to grow, blockchain's ability to provide a robust, tamper-evident record of ownership and usage represents a promising solution for the entertainment industry. Continued innovation in layer-2 scaling solutions, the development of industry standards, and proactive regulatory engagement will be crucial for overcoming current obstacles. Ultimately, collaborative efforts among technology providers, policymakers, and content creators may accelerate the transition to a future in which creators maintain unprecedented control and clarity over how their works are distributed, monetized, and protected. This evolution will be particularly significant as immersive environments like the Metaverse become increasingly important platforms for content creation, distribution, and monetization. Future research directions should explore how blockchain-based DRM frameworks can be adapted to protect digital assets and transactions within the rapidly evolving Metaverse ecosystems.

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