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The effects of blockchain in the music industry. How the copyright management is going to change: a case study from SIAE

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Politecnico  
di Bari



UNIVERSITÀ  
DEGLI STUDI DI BARI  
ALDO MORO

Riccardo Carnevale

## The Effects of Blockchain in the Music Industry

How the copyright management is going to change: a case study  
from SIAE

**Thesis submitted for the degree of Philosophiae Doctor**

Interuniversity Ph.D. Program in Industry 4.0  
Politecnico di Bari

### **Tutors**

Prof. Engr. *Eugenio Di Sciascio*

Dr. Engr. *Domenico Lofù*

**2026**



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# 1. Introduction

## 1.1 Motivation

The technology behind blockchain in recent years has found its application in a wide variety of industries, as well as transversality in making internal processes transparent and immutable so as to ensure authenticity and protection of a product or service. In a market that increasingly views data as a new asset deserving of protection, the Blockchain is a genuine solution in the tracking and collection of data, as well as a tool for making businesses scalable and more secure. Within this discourse is the case study that is the subject of this research, namely the collaboration between Algorand, one of the best-known blockchains globally, and the Italian Society of Authors and Publishers (SIAE) to create a blockchain-based platform for transparent and efficient management of copyrights held by the latter.

Algorand represents the latest frontier in the DLT sector and is characterized by the ambition to overcome the blockchain trilemma, the presence of a dual layer architecture and the potential to create auxiliary co-chains interoperable with each other. This way, traditional models can be converged with decentralized systems, ensuring security and scalability. Thus this new technology came to be: a blockchain infrastructure capable of handling large volumes of transactions thanks to the Pure Proof-of-Stake (PPoS) consensus protocol, patented by Prof. Silvio Micali, and aiming to materialize the concept of FutureFi, the “Future of Finance”. Algorand counts 500

companies around the world that have signed up for its internal adoption, including the aforementioned SIAE, a society operating in the collective management of copyrights for 140 years in Italy, which decided to revolutionize and open up to blockchain technology.

The partnership was launched in 2019 and sees a first important milestone two years later, in March 2021, with the development of an platform based on blockchain technology, with the creation of four million digitized copyrights of more than 95,000 SIAE artists in the form of NonFungible Tokens (NFTs), unique and unchangeable digital assets tracked on blockchain. This showed SIAE's ambition to be an international paradigm in the sector, as well as becoming the point of reference for all collective rights management societies. The open perspective with which the platform was developed aspires to massive global adoption for the achievement of true decentralization of copyright management, thereby enabling authors themselves to have full governance of digitized assets representing their rights. This is an example of how the art and music market can change its business model and how their intermediaries can enact this change. It allows for a medium to long term vision that will allow for transparent, efficient, decentralized and scalable copyright management, as well as making SIAE a forerunner and driver of this fast and profound change and setting the tone to all other foreign players in this business arena.

The aim of this research is to study in depth the copyright intermediation market and the kind of technological solution developed by Algorand for SIAE, analyzing the

functioning of the co-chain rights management platform. The benefits in terms of efficiency and transparency compared to the traditional model will be highlighted in order to confirm the premises, explaining the individual advantages both at system level in an analytical manner, as well as future developments.

How the blockchain technology might emerge as a disruptive force in the music industry is the central point of this research. It analyzes what technological changes mean for the increasing and distributing music industry revenues. However, this cannot be done without first reviewing the literature in the field of copyright management and the impact that digital technology has had in recent years.

## **1.2 Literary review**

Over the years, literature has predominantly focused on intellectual property (IP) and copyright as legal instruments designed to protect creators (Hanel, 2006; Varian, 2005). In contrast, relatively limited researches have addressed collective management organizations (CMOs), the entities responsible for safeguarding these rights.

CMOs are institutions entrusted with administering copyright on behalf of a large number of right holders (Gervais, 2015). Such organizations may be established either through private agreements or by state authorities, depending on the copyright legislation in force within a given jurisdiction. Members of a CMO license their copyrights to the organization, which in turn licenses the protected works to third

parties, collects royalties, and distributes them to the respective right holders. Historically, this activity has been confined to copyrights related to literary, dramatic, and musical works, as well as other publicly performable creations (Chafee, 1945).

The limited body of research on CMOs has primarily examined how recent digitalization trends have affected the music industry as a whole. With the advent of new technologies, among the most recent being blockchain and non-fungible tokens (NFTs), both the music industry and CMOs have encountered novel challenges concerning the management of intellectual property (Kapsoulis, 2020; Lewis et al., 2021; Malik et al., 2023).

Blockchain technology constitutes a peer-to-peer ledger that collectively records information and data in blocks, which are then linked together to form a literal “chain” (Narayanan et al., 2016). The literature has explored numerous potential applications of blockchain (Mougayar, 2016), including its implementation within the music market (Silver, 2016; O’Dair, 2016; Lemieux, 2016), particularly as an operational database for managing royalty distribution and enhancing transparency (Sitonio & Nucciarelli, 2018; Savelyev, 2018; Tam, 2019).

Supporting these premises are several case studies, including the one analyzed in this research, that illustrate blockchain’s diverse uses in the music industry (Kim & Kim, 2020; Zhang, 2024). One notable example (Hoang, 2023) is Audius, a decentralized music streaming platform that enables users to publish and listen to

music without paid subscriptions. Unlike centralized systems, revenue management on Audius is autonomously handled by right holders. The platform operates through Audio, a token based on the ERC-20 technical standard, used on the Ethereum blockchain to create and manage tokens (Shirole et al., 2019). This standard also enables asset exchange across other blockchains such as Solana (Yakovenko, 2018), where much of the platform's tokenomics is developed (Cong et al., 2021; Freni et al., 2022). Files containing the uploaded musical works are stored using the InterPlanetary File System (IPFS) protocol, which ensures decentralized and distributed preservation and sharing through a peer-to-peer network (Benet, 2014).

Another activity that has received substantial literature attention (Panay, 2016; De Leon & Gupta, 2017; Arcos, 2018) is the Open Music Initiative (OMI), a project led by the Berklee College of Music Institute for Creative Entrepreneurship in collaboration with the MIT Media Lab, supported by major record labels, streaming services, publishers, collection societies, and nearly sixty other founding entities. OMI's mission is to promote the creation of open-source standards and foster innovation within the music industry, with the ultimate goal of ensuring fair compensation for all artists holding rights. Rather than functioning as a database, OMI provides an open-source technical architecture comprised of core functional blocks and APIs that will allow developers and stakeholders to build their own systems and tools that are OMI, including several blockchain-based projects created through a music lab launched in collaboration with the Inter-American Development Bank (IDB).

Blockchain technology can also serve as a means to combat piracy by enabling authentication and certification mechanisms for any type of digital data (Meng et al., 2018; Peng et al., 2019). Within this framework, the phenomenon of non-fungible tokens (NFTs) emerges (Anjum & Rehmani, 2022; Bai et al., 2022). Although most studies have concentrated on the technical aspects and potential applications of NFTs in financial (Aharon & Demir, 2022; Dowling, 2022) and healthcare contexts (Chiacchio et al., 2022), there is an increasing trend toward exploring new avenues of adoption (Nadini et al., 2021; Wilson et al., 2022; Nevi, 2022), including their potential integration with copyright ownership (Chalmers et al., 2022).

The literature on these technological innovations is therefore rapidly expanding, driven by the continuous experimentation and implementation of diverse applications over time.

### **1.3 Methodology**

For the present research, the case study method will be adopted (Noor, 2008). The selected case, as previously mentioned, concerns the solution developed by SIAE, the Italian Collective Management Organization (CMO), which seeks to provide the tools necessary for transitioning from a centralized system to a decentralized one, without completely disrupting the current framework of copyright management. Specifically, the project aims to record on-chain the information contained within a

centralized database concerning copyright ownership and the corresponding agreements between right holders and CMOs.

The analysis of a single case study allows for an in-depth exploration of the underlying themes (Flyvbjerg, 2006). This study is supported by other studies conducted on the same platform (Nevi & Dezi, 2022; Vitaletti & Zecchini, 2023; Della Monica et al., 2025) and has been further enriched through a direct interview with Matteo Fedeli, the current General Manager of SIAE. He not only oversaw the conception and subsequent development of the project from its inception, when he was Director of the Music Division of the Italian CMO, but also strongly advocated for its realization, among other things, by securing and winning a ministerial funding call<sup>1</sup>, emphasizing his vision that SIAE should actively pursue this innovative trajectory.

In this regard, he stated during the press announcement of the project that “as a non-profit organization, one of the main goals of SIAE is to provide the highest quality of service for its members, while at the same time minimizing the need for their economic support”. He further added that “as a consequence, a future in which the transactions to remunerate rights holders will be fully automated is absolutely within the scope of SIAE’s mission, and for these reasons, we believe that a decentralized future is plausible, and it could be incrementally realized, leading the change”<sup>2</sup>.

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<sup>1</sup> MiSE’s 5G Emerging Technologies Support Program

<sup>2</sup> <https://www.dday.it/redazione/33444/siae-progetto-blockchain-diritto-autore>

This perspective explains the rationale behind the decision to investigate blockchain technology and its significant impact on the creative industries.

The focus of this research lies in analyzing the transformation of the business model and innovation management practices adopted by CMOs, understood as the central link in the music industry's value chain, responsible for the protection, promotion, and dissemination of intellectual property. The analysis is supported by data relevant to addressing the key issues identified through the case study.

This paper is divided into three core sections followed by a conclusion. The first section briefly introduces blockchain technology, outlines the recent evolution of the music industry, and examines how blockchain may influence it. The second section analyses the current centralized copyright management model operated by collective management organizations (CMOs) and explores the possible architecture of a decentralized alternative. The third section investigates the selected case study, illustrating how SIAE developed the platform, its operational mechanisms, the associated opportunities and challenges, potential future developments with smart contracts and the current status of the project. The final section presents the conclusions and an evaluation of the project.

## **2. New technologies and impact on the music industry**

New technologies are not a sector in themselves but rather a tool that cuts across and impacts a wide range of industries. Their disruptive nature, influencing various aspects of everyday life, is often described with the term disruptive (Danneels, 2004), which aptly conveys the profound changes they bring to traditional contexts. Among the many that have emerged in recent years, Blockchain has certainly been one of the technologies whose benefits for adoption are still debated (Yli-Huumo et al., 2016) and require careful analysis to assess their impact in each specific case.

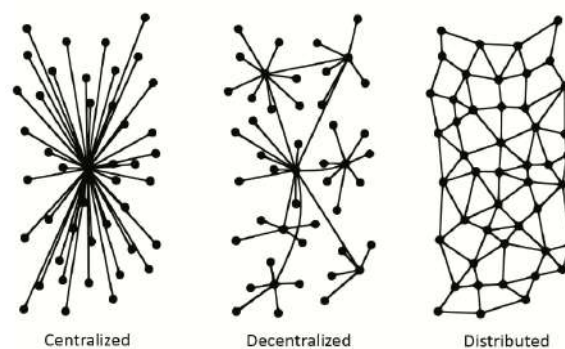
In this context, the music industry has already undergone adjustments with the transition into the digital era. With the advent of streaming services, music consumption has shifted from the concept of physical ownership to that of content access. Consequently, the traditional flow of money in this sector, from listener to artist, has had to adapt to these new consumption models.

Given the rapid changes shaping music consumption and creation, it has become necessary to update the monitoring and attribution of musical works, as well as streaming plays and downloads. In this way new technologies can be applied to radically simplify the way music rights owners are identified and compensated, resulting in sustainable business models for artists, entrepreneurs, and music

businesses alike (Panay, 2016), and blockchain technology has the potential to transform the entire copyright supply chain (Iansiti & Lakhani, 2017).

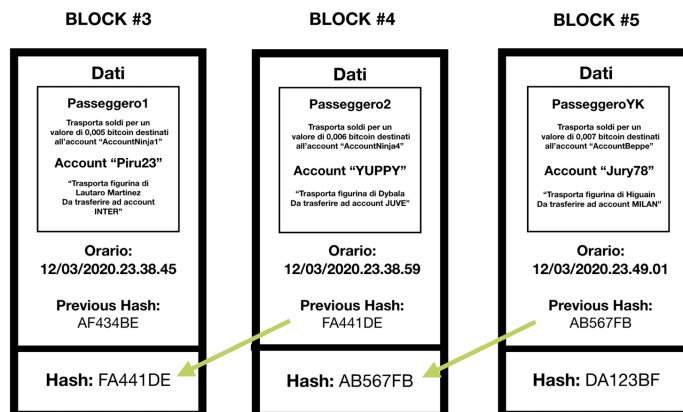
## 2.1 What is Blockchain?

The Blockchain cryptographic protocol, as originally envisioned by Satoshi Nakamoto, is an open-source software, called “Bitcoin Core”, operating on a peer-to-peer (P2P) network, in which transactions occur exclusively between the nodes of the system, without the need for intermediaries (Nakamoto, 2008). The system enables the allocation and transfer of file ownership, while Bitcoin, the unit of currency generated within the protocol, is intangible and consists of alphanumeric strings. These records are inscribed on the blockchain, a ledger that stores all executed transactions and remains publicly accessible to the network’s nodes. The blockchain thus constitutes a vast database: a decentralized, encrypted, shared, and distributed online register maintained collectively by all servers participating in the network.



*Fig. 1 Difference between centralized, decentralized, and distributed systems (Kerényi & McIntosh, 2019)*

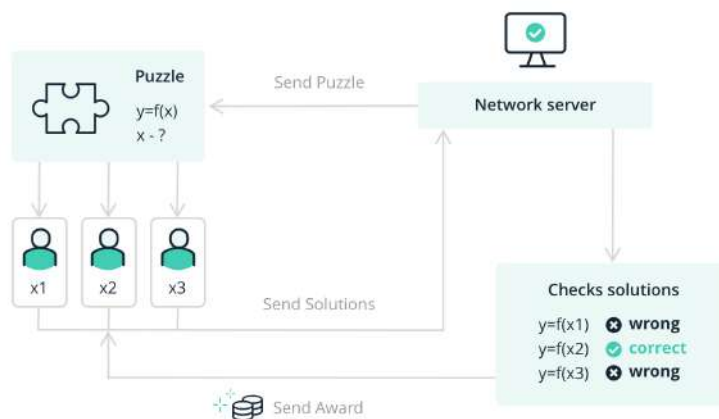
Cryptography and the underlying decentralization ensure the immutability, incorruptibility, and transparency of the data stored within the system. This is made possible through the creation of interconnected blocks<sup>3</sup>. The term Blockchain refers to a chain of blocks, each of which contains the transactions executed as well as the record of all preceding ones. Once a block reaches its storage capacity, it is sealed by means of a cryptographic key which, after being converted into a code through a hash function, is inserted as the first piece of information in the subsequent block, thereby binding the two together in an indissoluble manner. The hash function is a non-reversible operation that allows you to map a text and/or numeric string of variable length into a unique string of fixed length called a digest; the resulting digest uniquely and securely identifies each block, and a hash must not allow you to trace the text that generated it.



*Fig. 2 Example of block concatenation using a hash function*

<sup>3</sup> A block represents a collection of transactions that are joined together to be verified, approved, and then stored by blockchain participants.

The distinctive and compelling features of the blockchain lie in its uniqueness, independence from central authorities, irreversibility of recorded transactions and their traceability, as well as the programmability and continuous improvement of the software by user communities. The activity that enables the functioning of this system is known as mining, and the reward for the work performed is Bitcoin, the cryptocurrency issued by the blockchain. Mining engages network participants (miners) with high levels of computational power through a specific consensus mechanism, which validates all transactions occurring on the blockchain. This function, also referred to as Proof of Work (PoW), operates through the resolution of a “mathematical puzzle”. Miners compete to obtain a reward by submitting to the network proof of solving the complex computational problem. Approximately every ten minutes, the first miner to reach the solution, by providing the computational power of their servers to the network, receives the cryptocurrency as compensation.



**Fig. 3** Miners in a PoW Consensus.

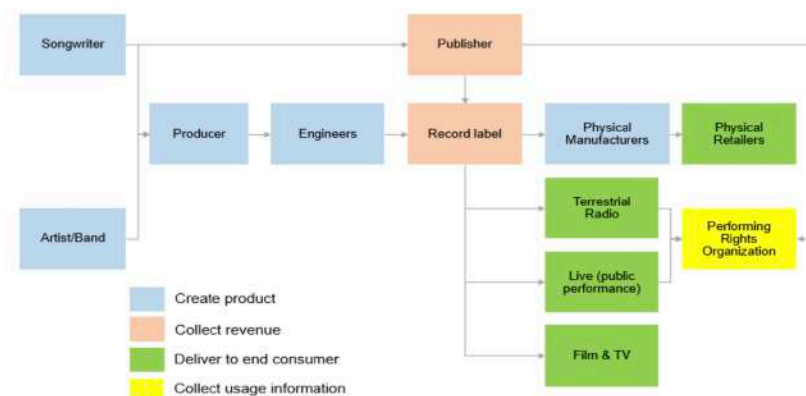
This system ensures the verification of the accuracy of transcribed information as well as the chronological ordering of blocks. The entire blockchain is continuously updated and synchronized, enabling all participants to demonstrate ownership or analyze data at any given time. For these reasons, this technology has proven successful not only in the financial sector, through the creation of cryptocurrencies, but can also be applied across a wide range of contexts in which information must be recorded and preserved in an immutable and transparent manner without the need for intermediaries (Crosby et al., 2016). Among its many applications is its use in the music industry, particularly with regard to the management of royalty payments (Tam, 2019).

## **2.2 How works the music industry**

When approaching the vast domain of the music industry, it is important to clarify that this sector is fundamentally grounded in the creation and exploitation of music-based Intellectual Property (IP). In the activities that follow the production of a work, three principal macro-areas of the music industry can be identified: performing, recording, and licensing (Wikstrom, 2014). The first concerns the live reproduction of music by the artist, such as in a concert. The second refers to the recording and distribution of a musical work to consumers. The third, instead, involves the licensing of music for various uses, such as in advertising. Among these three sub-industries, attention will now be directed toward a brief historical overview of the evolution of the

recorded music industry in recent decades, in order to better understand how blockchain technology may find effective application in this context.

In the 1990s, the recording industry dominated the global cultural economy through a business model centered on the sale of physical media, most notably the Compact Disc (CD), sustained by major labels such as Universal Music Group, Sony, Warner Music Group, BMG, and EMI, commonly referred to as the “Majors”. These companies held monolithic power over the production, promotion, and distribution of the most prominent musical works. The pre-Internet era represented the apex of this system, which at the time reached a market value of \$38.6 billion (IFPI, 2001). The record labels’ complete control over the entire supply chain was characterized by high profit margins, promotional campaigns orchestrated through radio, television, and large retail chains, and a high perceived value of recorded music. Within this vertically integrated supply chain, record labels functioned as the central node for reaching the final consumer.



**Fig. 4** Recorded Music Supply Chain: Prior to the digital era (Hosoi et al., 2015).

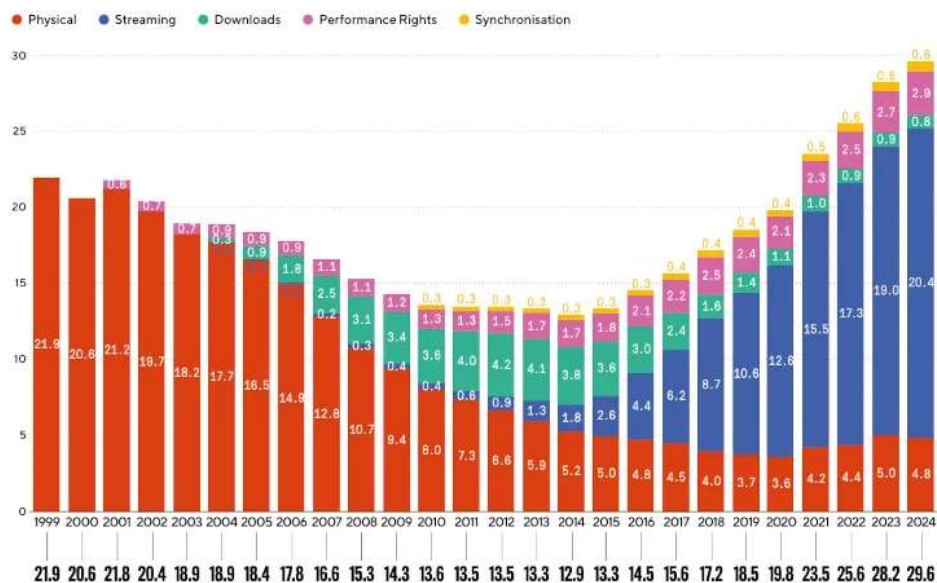
However, with the advent of digital technologies, the industry began to experience technological and cultural tensions that would ultimately undermine this model. The MP3 format, enabled by audio compression and accelerated by the diffusion of the Internet, introduced new forms of music sharing and access that stripped record labels of much of their control. The Majors initially attempted to respond to these emerging business models by preserving the existing structure of the industry. The most striking example was the lawsuit against Napster (Ku, 2002), a P2P music-sharing network that significantly increased music piracy. The transition to the digital model became irreversible in the early 2000s, as the market for physical media experienced a sharp decline in sales. In the United States, according to data from the International Federation of the Phonographic Industry (IFPI), revenues fell from \$14.6 billion in 1999 to only \$6.3 billion in 2009, while worldwide revenues from CDs, vinyl, cassettes, and digital downloads decreased from \$36.9 billion in 2000 to \$15.9 billion in 2010. In response to this negative trend, a recovery phase began with the adoption of the Internet by record labels for the commercialization of music. One of the most significant turning points was the launch of Apple's iTunes platform in 2003, which paved the way for the paid digital sale of individual tracks and albums, reshaping the centrality of the album format and fostering new promotional and consumption strategies. Music was no longer a physical good; consumers could purchase digital media content across all their devices without additional restrictions. Musicians, however, began to complain of insufficient royalty payments under this new distribution model due to the low sales price, while the record label market underwent

consolidation, with the merger of Sony and BMG in 2004 and Universal’s acquisition of EMI in 2012, reducing the industry to three major players capable of asserting dominance even in the digital transition.

	<i>Global recorded music market (%)</i>	<i>Streaming music market (%)</i>
<b>Universal Music</b>	28.9	30.4
<b>Sony Music</b>	22.4	22.7
<b>Warner Music</b>	17.4	18.6
<b>Total Majors</b>	68.7	71.7
<b>Independent labels</b>	31.3	28.3
<b>Total market</b>	100.0	100.0

*Table 1 Majors' market share on the worldwide recorded music market in 2016 (Aly-Tovar et al., 2020).*

The true paradigm shift, however, came with streaming: services such as Spotify, founded in 2008 and expanded globally from 2011, and platforms like YouTube shifted the focus from ownership to on-demand consumption through subscription or freemium models, thereby redefining both the industry’s economy and its relationship with creators. From 2013 onwards, streaming became the primary driver of the market, reversing the downward trend and enabling the industry to return to growth. To illustrate, the global value of recorded music reached approximately \$29.6 billion in 2024, marking a 4.8% increase compared to the previous year; streaming accounted for nearly 69% of total revenues in 2024, generating over \$20.4 billion (IFPI, 2024).

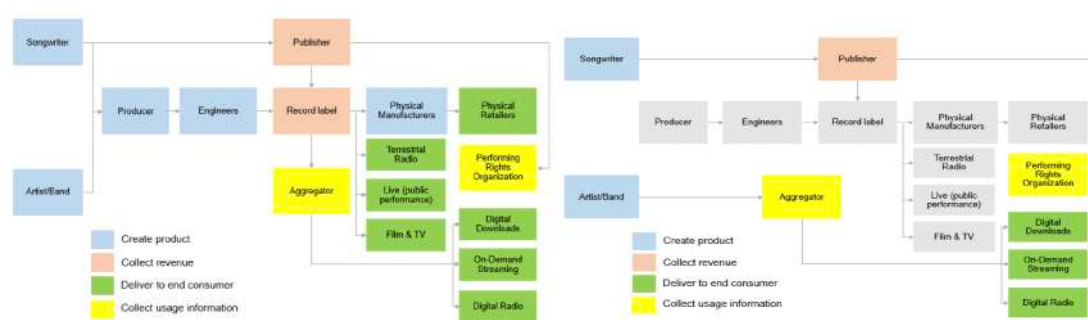


**Table 2** Global Recorded Music Industry Revenues 1999-2024 in \$ billions.

The phenomenon of streaming has also led to global dissemination through easier, faster, and unlimited access to musical IPs. In Europe as well, the sector has contributed significantly to economic growth, supporting millions of jobs and generating over €5 billion in recorded music revenue, with streaming surpassing \$5 billion in the region for the first time in 2023 (WIN, 2024). This new context has not been without challenges: the industry has consolidated the power of the major labels, new algorithmic platforms have influenced music consumption towards shorter tracks, curated playlists, and functional content, while many artists have lost control over their creations and reported insufficient remuneration relative to the volume of streaming generated, highlighting the inequalities in revenue distribution (Hesmondhalgh, 2021).

## 2.3 The value of copyright in music industry

In this transformed musical ecosystem, where consumption has shifted from the purchase of physical media to subscription-based unlimited digital playback, the structure of the industry has remained vertically integrated. Artists create the musical product, fans pay for the opportunity to access and play the tracks, and record labels and distributors act as intermediaries between the two entities (Graham et al., 2004).



**Fig. 5** Recorded Music Supply Chain: Digital era, Major artists on left and small artists on right (Hosoi et al., 2015).

Creative professionals in the music industry, including singer-songwriters, producers, and musicians, often lack transparency regarding royalty calculations and have limited access to aggregated data on the consumption of their works (Heap, 2017). Within this framework, Collective Management Organizations (CMOs) play a crucial role. Collective management represents the most common mechanism in the copyright system, with CMOs acting as intermediaries responsible for the collection and distribution of rights associated with the public use of intellectual property (Narayanan, 2007).

While record labels are primarily responsible for producing, marketing, and promoting artists' works, receiving in return a substantial share of royalties, CMOs focus on administering these royalties from distributors and any other entities that publicly utilize copyrighted intellectual property (IP). The principal functions of a CMO can be summarized as follows:

- Monitoring when, where and what works are used;
- Negotiating tariffs and other conditions with users;
- Granting licenses for the use of protected works on behalf of members and other rights holders represented;
- Collecting tariffs from users and distributes them to rights holders.

CMOs operate in the interests of artists, performers, and producers, facilitating the exploitation of IP by third parties while ensuring that rights holders receive appropriate economic compensation (Street et al., 2018). For example, in the context of radio broadcasting, it is impractical for individual artists to negotiate licenses and remuneration with every station, and similarly, radio broadcasters cannot feasibly contact each rights holder for permission to use each track. Consequently, copyright management has been centralized through CMOs, which possess the authority to act on behalf of rights owners, monitor the usage of IP, and oversee the collection and equitable distribution of royalties.



**Fig. 6** *The role of a CMO.*

When an artist fully delegates authority to a CMO, they must place considerable trust in a centralized structure, without having the ability to independently verify the accuracy of its operations. The limited number of CMOs, combined with their dominant role in negotiating tariffs and conditions, grants them exclusive access to critical information that generates substantial revenue, as well as a strategic advantage over other stakeholders.

While the efficiency of this system is evident, enabling the delegation of complex negotiation and royalty collection tasks to specialized third parties, the lack of transparency in the flows between the various actors can undermine the assurance of equitable market opportunities (Panda & Patel, 2012) and result in lower royalty collections. In contexts where greater transparency is required, blockchain technology emerges as a promising solution to enhance visibility and accountability (Kapsoulis et al., 2020; Arenal et al. 2023).

### **3. A proposal for decentralizing copyright management**

The adoption of blockchain technology in copyright management has the potential to reduce the influence of Collective Management Organizations (CMOs) in their intermediary role, while providing greater transparency and traceability of the financial flows related to royalties owed for the public use of musical intellectual property. A decentralized blockchain-based platform could enable a future in which the online streaming of a song automatically triggers a transaction that remunerates rights holders in real time. In this way, the work of CMOs in revenue collection could be automated and, to some extent, replaced (Ito & O’Dair, 2018). Moreover, due to its inherently transparent nature, blockchain would create a more dynamic and equitable environment and offer new opportunities for all stakeholders involved in copyright. In this context, the Italian Society of Authors and Publishers (SIAE) has initiated the development of a public and accessible platform capable of addressing this emerging need<sup>4</sup>. Anticipating a potential paradigm shift in which the artist is repositioned at the center of the system, SIAE aims to be prepared for a possible business model transformation, offering its members an advanced interface shared with other CMOs. The objective is not to resist innovation but rather to interpret and adapt to the transformation that the intermediary sector is poised to undergo.

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<sup>4</sup> SIAE site: <https://www.siae.it/it/notizie/siae-algorand-blockchain/>

### **3.1 Collaboration between SIAE and Algorand**

SIAE is the Italian CMO and was founded in 1882. It is a public body with economic interests based on membership. For more than 140 years, SIAE's mission has been to ensure that authors and publishers receive protection and remuneration for the work they produce. In pursuit of this objective, it has recently initiated an investigation into the use of the most effective technologies to support its mission. As a non-profit organization, one of its primary goals is to provide the highest quality of service to its members while minimizing the need for their financial contributions. Consequently, the implementation of technologies that automate processes and payments aligns fully with its mission. In aiming to pursue decentralization and transparency in copyright governance processes, SIAE has identified Algorand as the most suitable partner for developing a blockchain-based project.

Algorand is a blockchain technology described by its founders as public, permissionless, and next-generation. It aspires to incrementally provide a comprehensive set of tools for the main use cases that can be implemented through blockchain technology. The project originated from the academic research activities of its founder, Silvio Micali, and its development follows an open-source approach (Chen & Micali, 2016). After initiating a practical experimentation of the theoretical framework, in 2019 Silvio Micali founded Algorand Foundation and Algorand Inc. The former is a non-profit organization responsible for defining the monetary economy

(tokenomics) of Algo, Algorand's native cryptocurrency, monitoring and supervising its distribution within the network, establishing partnerships with universities, associations, and companies to fund research and development of use cases, and planning marketing and public relations activities. The latter is a private company based in Boston that provides support services to developers and implements the open-source software for the Algorand Foundation, in addition to participating in events.

Algorand's consensus protocol is called Pure Proof of Stake (PPoS). Unlike Bitcoin's Proof of Work (PoW), which relies on miners' computational power, Proof of Stake (PoS) assigns weight to users based on their ownership of a given cryptocurrency. Specifically, Algorand's protocol is based on a decentralized Byzantine Agreement algorithm (Gilad et al., 2017), which assumes security as long as at least two-thirds of the "online" stake is controlled by non-malicious accounts. Each transaction block is considered valid if certified by a quorum of randomly selected stake-holders. The cryptographic algorithm that selects users is called a Verifiable Random Function (VRF), which calculates a probability proportional to the amount of Algo held. This mechanism allows Algorand to be considered a "Trilemma solver" (Fu et al., 2024), as it achieves performance across the three key blockchain dimensions (scalability, security, and decentralization) without compromising any of them (Werth et al., 2023). Every network participant can take part in decision-making simply by holding Algo in their digital wallet, without the need to lock their tokens as required by traditional PoS protocols. Successfully attacking the blockchain would

require controlling an excessively large share of the circulating cryptocurrency, making Algorand secure by design. Additionally, since no mining is involved, computational power consumption - and therefore electricity usage - is minimal, while block production speed remains high. This enables the network to handle a large number of transactions per second with minimal energy expenditure.

To better understand how Algorand's blockchain technology can be practically implemented, it is first necessary to take a step back and examine how copyright information is currently organized at the international level among the various CMOs, each delegated by territorial competence, and consequently analyze the Interested Party Information (IPI) system.

### **3.2 Overview of the IPI system**

The IPI is an international information system containing data on all rights holders whose rights are managed by Collective Management Organizations (CMOs). The IPI system provides a clear and unambiguous identification of rights holders at a global level, enabling the determination, at any given time, of which rights are protected, by whom, and in which territories for each natural or legal person. This is crucial not only for data exchange among CMOs but also for the worldwide sharing of information with third parties such as streaming platforms and radio or television broadcasters. The system is managed by SUISSse Auteurs (SUISA)<sup>5</sup> and is utilized by the International

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<sup>5</sup> Swiss Cooperative Society for Music Authors and Publishers.

Confederation of Societies of Authors and Composers (CISAC)<sup>6</sup> and the Bureau International des Sociétés gérant les droits d'enregistrement et de reproduction mécanique (BIEM)<sup>7</sup>. Le informazioni al suo interno sono registrate secondo il Common Information System (CIS). The information contained within the system is recorded according to the Common Information System (CIS). The following table summarizes the relevant information, providing a schematic example.

Heading	Short description	Example
Base_No	Interested Party (IP) base number, unique identifier of a right holder	E.g. I-001450581-6 identifying the right holder
Name_No	IP name number, additional identifier of a right holder	E.g. 41161231 identifying a pseudonym of the right holder
NT	Name Type	Patronym
Name	IP Name	E.g. Rossi Mario
CC	Creation Class	E.g. Musical Work (MW)
RO	Role	E.g. Musical creator (MC)
RI	Right	E.g. Performing Right (PR)
CMO	Collecting Society	E.g. SIAE
Valid_from	The date from which the right management is given to CMO	2009-05-06
Valid_to	The date until which the right management is given to CMO	2045-10-20
Share	The percentage of right the CMO is in charge to collect	E.g. 100%
TERR	The territory in which the CMO is in charge of the right management	E.g. Italy

**Table 3** IPI main fields.

In examining the Table, the tuple {CC, RO, RI, TERR} identifies an artistic right of the rights holder. Specifically, it denotes a right (RI) pertaining to a category of artistic works (CC) in which the rights holder has participated with a particular role (RO). The tuple {Name\_No, CMO; CC, RO, RI; Share, TERR, Valid\_from, Valid\_to}

<sup>6</sup> CISAC is the global confederation of authors' societies, which protects and promotes copyright in the fields of music, audiovisual, literature, and visual arts.

<sup>7</sup> BIEM is the international body that coordinates collective management societies for mechanical reproduction rights for musical works (e.g., copies on CDs, downloads, streaming).

represents an agreement between the rights holder (Name\_No) and a collective management organization (CMO), valid for the time interval (Valid\_from, Valid\_to) and within a given territory (TERR). In essence, these fields indicate that, during the period between Valid\_from and Valid\_to and within the specified TERR, Name\_No has assigned to the CMO a defined share of the management of their artistic rights (CC, RO, RI).

Additional metadata not included in the Table but required for record compilation concern the attributes of the author, which differ depending on whether the author is a natural person or a legal entity.

The IPI system provides three main functionalities for its users:

- Creation of a new record;
- Retrieval of records associated with a specific author through either the author's identification number or that of the IP;
- Updating, and potentially deleting, an existing record.

The development of a decentralized attribution ledger must therefore be capable of replicating the same data structure and functionalities, while addressing the issues inherent in a decentralized system:

- Reliance on a single uncontrolled entity, i.e., a "single point of failure";

- Synchronization between copies of the central system;
- Conflicts arising from asynchronous updates over time.

Moreover, given the volume of data managed by the IPI system, the new system must be able to handle on the order of one billion records on the ledger.

### **3.3 Architecture of a decentralize system**

SIAE, taking the IPI system as a model, has replicated its functioning on the Algorand blockchain through the creation of digital tokens that describe an artistic right within a specific territory. These tokens, which internally encapsulate the essential information of the individual copyright, are non-fungible. Each right managed by a CMO must be formalized through an agreement between the parties in order to be registered on the blockchain. The conclusion of such an agreement entails the transfer of the Non-Fungible Token (NFT) from the rights holder to the receiving CMO (Wang et al., 2021). The latter thereby becomes responsible for the protection of the user's specific right in the real world, as well as the entity holding the NFT on-chain. Nonetheless, the user always retains the possibility of directly managing their own copyright. For instance, an agreement may be concluded with another CMO for the transfer of the NFT via the platform. Since all operations of creation, and, where applicable, updating or deletion, must be jointly authorized by multiple parties, namely, the rights holder and a CMO, it is necessary that the adopted blockchain support multi-signature accounts, i.e., accounts requiring the cryptographic signatures of multiple

autonomous parties in order to publish new transactions on the blockchain. Finally, Algorand, with its ability to generate blocks in under five seconds and to process up to 1,000 transactions per second, can ensure satisfactory system performance in the event of increased network load, whether due to a large number of rights holders adopting the system or to the development of additional functionalities based on the IPI framework.

The NFTs that store the attributes of an artistic right on Algorand are implemented through Algorand Standard Assets (ASA). The ASA is a layer-1 feature that enables users to represent any type of asset on the Algorand blockchain, thereby benefiting from the same level of security and usability as the native Algo (Mirzaei, 2023). The Algo also serves as the underlying currency, since holders of an ASA must maintain a minimum balance of 0.1 Algo<sup>8</sup>. Moreover, through the opt-in mechanism, it is not possible to transfer an ASA unless the receiving party has explicitly consented to the transaction. In this way, both parties authorize the transfer, thereby mitigating the risk of human error or anomalous behavior. ASAs are employed on Algorand to represent a wide range of fungible and non-fungible assets, such as loyalty or in-game points, store credits, ticket sales, and many other activities.

In the case of SIAE, ASAs are composed of immutable fields (such as NT, Name, CC,

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<sup>8</sup> 100,000 microAlgos.

RO, RI, Base\_No, Name\_No, Valid\_from) and mutable fields (CC, Valid\_to, Share). The fields of an IPI database record are publicly readable on the blockchain, whereas those that SIAE - and, more generally, all CMOs - consider confidential in nature, such as personal data not suitable for public disclosure, can be managed off-chain. However, in order to preserve a strong linkage between confidential data and public on-chain data, it is advisable to include an anonymized string that maintains the reference from on-chain data to its off-chain counterpart. One possible solution to address this requirement is to incorporate, among the on-chain information concerning a Right Holder (RH), a hash of the confidential data, thereby providing a unique and immutable reference.

Public record on the blockchain		Private data off-chain	
NT	PA	Date of <u>birth</u>	01/01/1990
Name	Mario Rossi	City of <u>birth</u>	Roma
CC	MW	Attribute3	value3
RO	MC	Attribute4	value4
RI	PR		
CMO	SIAE		
Base_No	I-001450581-6		
Name_No	41161231		
Valid_from	2009-05-06		
Valid_to	2045-10-20		
Share (%)	100		
TERR	Italy		
hashPrivateData	509a83b2cea17da8..		

**Table 4** Data structure of an IPI record written in blockchain.

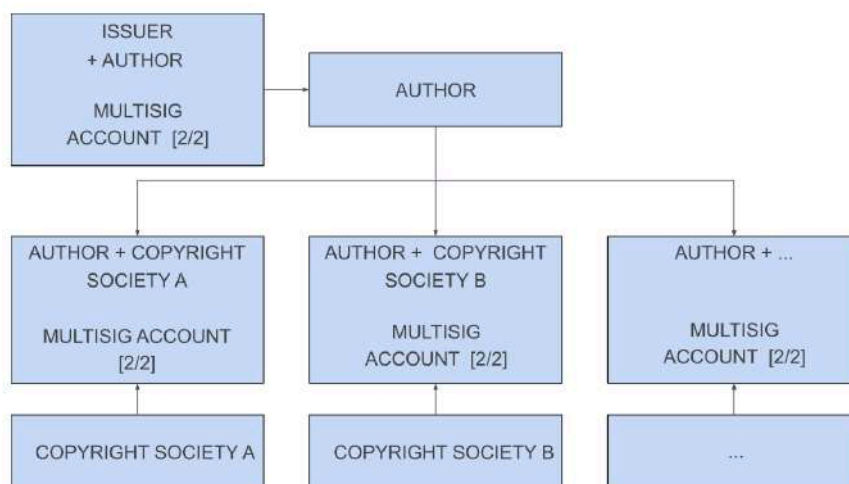
All users of the system are uniquely associated with a single blockchain account. However, the creation of an ASA must be agreed upon by multiple parties, so the token is created by an Issuer and a RH 2-of-2 multisignature account, which is the initial asset owner. Suppose that an RH needs to represent one of their copyrights through a digital asset on the blockchain in order to delegate its management to one or more CMOs. In such a case, the RH requests the issuer to generate a new and unique ASA corresponding to the artistic right. The ASA is then created jointly by the issuer and the RH through multisignature authorization (Issuer + RH). Once the ASA has been generated, the RH regains ownership of it and assigns its management to the CMO with which an agreement has been concluded, through the establishment of a new multisignature account (CMO<sub>1</sub> + RH). The agreement must include all the fields previously outlined in the IPI system and will be valid from the timestamp of transfer.

Heading	Short description	Cardinality	Example
<i>rh</i>	Rights holder identifier (e.g., IP base number, IP name number, IP name)		Rossi Mario
<i>cmo</i>	Collecting society	~200	SIAE, SUIISA
<i>ar</i>	Artistic right		
<i>cc</i>	Creation class	16	Musical work, dramatic work
<i>ro</i>	Role	34	Musical creator, book publisher
<i>ri</i>	Right	26	Performing right, re-transmission right
<i>terr</i>	The territory in which the CMO is in charge of the right management	220	Italy, France, Europe, North America, World
<i>valid_from</i>	The date from which the right management is given to the collecting society		01.01.2017
<i>valid_to</i>	The date until which the right management is given to the collecting society		31.12.2017

**Table 5** *The fields of an agreement.*

When issuing an ASA, the issuer may define a set of authority accounts with different control powers, including the clawback address. In this case, the RH is granted the ability to forcibly transfer tokens from one account to another, without requiring the signature of the account holder currently in possession of them. Technically, the

clawback address of the ASA corresponds to the Algorand single address of the RH. In this way, the rights holder can, at any time, reclaim control of the ASA and reassign it to any other account. When the RH decides to change the entity responsible for managing the artistic right, they regain ownership and transfer it to the new CMO through a multisignature account (CMO<sub>2</sub> + RH). The temporal values marking the closure of the old agreement (Valid\_to) and the beginning of the new one (Valid\_from) will coincide with the timestamp of the transaction.

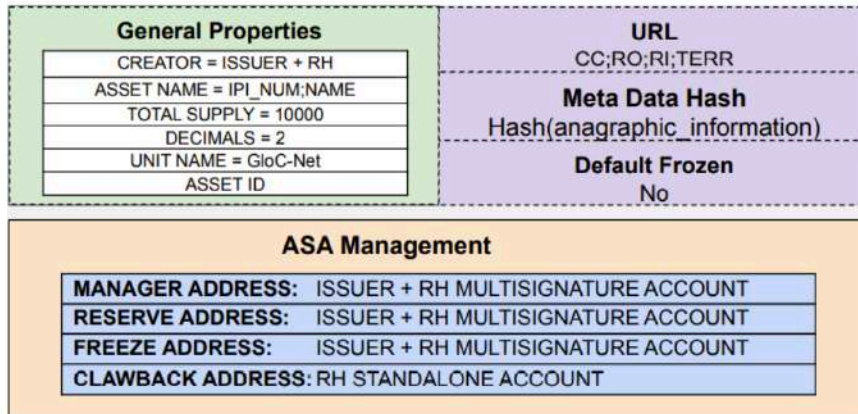


**Fig. 7** Role and architecture of management of an ASA (Vitaletti & Zecchini, 2023).

This process involves three different actors: the rights holder (RH), one or more asset issuers, and one or more CMOs. The necessary condition for the system to operate in the most effective way is that the issuer can be trusted to create valid ASAs that are not duplicates of intellectual property already registered. In performing this task, the issuer's account may be managed in different ways depending on the governance

model of the system. It could consist of a single entity (e.g., a single CMO) or multiple accounts, one for each CMO, operating independently yet consistently with one another so as to enable multi-issuance. To allow for greater decentralization in the issuance of tokens, the activity could alternatively be entrusted to a multisignature account jointly managed by several CMOs, or to a smart contract ruled by its own code.

In describing the structure of an ASA, the information concerning the artistic right {CC, RO, RI} and the territory (TERR) is stored in the asset parameters (URL). The URL {CC, RO, RI, TERR} belongs to the immutable fields of the ASA. As already noted, the Valid\_from and Valid\_to values can be implicitly determined from the timestamps of the ASA transfer transactions. The percentage of the share is specified through the combination of the total supply (set to 100) and decimals (set to 2) parameters. Used together, total supply and decimals enable the rights holder to allocate any portion of the 100.00% share to one CMO (e.g., SIAE) and another portion to a different society (e.g., SUISA), while simultaneously preventing any double-spending of the share. Within this solution, the Metadata Hash field of each ASA stores the hash value of the IP's private personal data, thereby ensuring the possibility of verifying the integrity of such data at a later stage.



*Fig. 8 Structure of a non-fungible ASA token (Della Monica et al., 2025).*

The architecture proposed by SIAE to implement a blockchain-based IPI system using Algorand is called the Global Creator Network (GloCNet). The project is structured such that, initially, the creation of the asset is partially centralized, while the subsequent management of the asset is decentralized. Over time, the objective is to fully decentralize the initial phase as well, so that the rights are directly managed by their respective holders in the future.

## 4. Case Study: SIAE's GloC-Net

The GloC-Net architecture presented in the previous chapter was developed between 2019 and 2021 by SIAE, following the organization's successful participation in a call for proposals by Italian Ministry of Economic Development (MiSE). This initiative outlined specific objectives aimed at increasing the efficiency of copyright management and, consequently, enhancing the overall effectiveness of the society's core activities. Specifically, on March 26, 2019, MiSE approved the "Support Program for Emerging Technologies Utilizing 5G Connectivity"<sup>9</sup>. The goal of this program was to promote experimental projects, applied research, and technology transfer initiatives based on the use of emerging technologies, such as Blockchain, Artificial Intelligence (AI), and the Internet of Things (IoT), in connection with the development of next-generation networks. As such, public administrations, institutions, agencies, and universities were eligible to apply for the implementation of innovative projects involving collaboration among multiple public and private entities.

The call required the participation of a leading proponent, the mandatory involvement of at least one public research institution, and the collaboration of an operator holding frequencies suitable for 5G use. Funding was provided through the Fondo Sviluppo e Coesione 2014-2020 (Development and Cohesion Fund 2014-2020), as part of the Investment Plan for the expansion of ultrafast broadband networks. At

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<sup>9</sup> <https://www.mimit.gov.it/images/stories/documenti/AVVISO-5G%20TECNOLOGIE%20EMERGENTI%20Definitivo%205.08.2019.pdf>

that time, SIAE had already begun exploring the applicability of Blockchain technology to copyright management; thus, upon publication of the call, it seized the opportunity to participate and proposed the GloC-Net project in order to obtain funding for its development.

#### **4.1 History and objectives of the project**

In seeking the partners required by the call for proposals, SIAE engaged WindTre S.p.A. as the 5G frequency operator and Sapienza University of Rome for the research component. On November 4, 2019, SIAE submitted its application containing the project details, and Algorand was subsequently selected as the technical partner for development. The opportunity to receive funding for the creation and testing of the platform, as well as for the implementation of the 5G network, enabled the concrete development of a project that had previously existed only at a theoretical level.

The use of the 5G network allows for the consumption of existing multimedia content at higher quality levels, as well as the creation of entirely new types of content thanks to its high bandwidth availability and low latency (Baratè et al., 2018). A key aspect of realizing these ambitions, both from a technical and an economic perspective, is the ability to manage and protect creative, audiovisual, and entertainment content, which will represent the majority of traffic on 5G networks (Zhang & Shao, 2025). As previously discussed, blockchain technology enables greater traceability of content and the corresponding distribution of remuneration to RHs, granting them direct control

over the management process. Its implementation will allow for the automation of current procedures, notably through the use of smart contracts (Hardjono & Pentland, 2019; Halgamuge & Guruge, 2022). These are coded translations of legal agreements capable of autonomously regulating relationships between parties by leveraging blockchain technology, thus decentralizing their operation. In the medium to long term, smart contracts will not only verify the proper use of a given piece of content by users in each context but will also autonomously manage the distribution of royalties to rights holders (Pons, 2017). The main challenge lies in overcoming the intrinsic limitations of centralized remuneration systems, particularly the difficulty of preventing unauthorized use of intellectual property and the lack of direct oversight over how major platforms exploit such content.

Currently, in Italy, it is impossible for a rights holder or their representative to challenge a Digital Service Provider (DSP), for example, a major music streaming platform, regarding the number of reproductions on which remuneration for the use of a given work is based. There are, in fact, no tools available to verify whether the number of reproductions declared by a DSP is accurate. The implementation of this model would therefore constitute a true paradigm shift. In summary, the project proposed by SIAE and developed in collaboration with Algorand, along with the research and 5G network partners, aims to eliminate the “value gap” that creators worldwide have long contested in relation to the dominant global digital platforms.

To bridge this value gap, the project was structured around two major objectives:

1. The development of an attribution ledger with standardized unique identifiers for rights holders;
2. The implementation of the attribution ledger on a decentralized blockchain system.

The first objective entails developing a platform capable of uniquely identifying copyright holders worldwide in relation to their intellectual works, thereby reflecting a cross-border ambition to become the global platform for copyright protection. In parallel, the second objective aims to implement the attribution ledger on a permissionless blockchain. The decision to pursue a permissionless system is intended to fully exploit blockchain's decentralization capabilities and to offer stakeholders a solution that anticipates a probable future in which many aspects of copyright management will be handled in a decentralized manner through blockchain-based infrastructures.

The project plan included specific targets and corresponding indicators to measure progress. For the first objective, the target was divided into three phases: an in-lab implementation of the attribution ledger to test all functionalities, demonstrate lower latency compared to the centralized solution, and verify scalability. Regarding the second objective, the plan emphasized the need for a study to identify the most promising blockchain and the development of a blockchain-based platform on that basis.

According to the project plan, a third step should have included that the attribution ledger manages economic flows directly on-chain, enable the certification of information related to content usage, and support intelligent content and dedicated hardware to combat piracy.

Based on this project framework, SIAE, acting as Lead Partner, was ranked first among the applicants in early January 2020<sup>10</sup>. In April of the same year, work began on the two main objectives, leading in March 2021 to the creation, on the Algorand blockchain, of 4 million NFTs digitally representing the rights of more than 95,000 SIAE member authors<sup>11</sup>. For the first time, copyrights were represented as digital assets on a decentralized and transparent public blockchain.

## **4.2 Bootstrap and cost analysis**

In March 2021, SIAE carried out the bootstrap phase on the Algorand Mainnet by transferring approximately four million artistic rights associated with intellectual properties (IPs) from the IPI System onto the blockchain, each represented as a distinct Algorand Standard Asset (ASA). The process of transferring and creating these rights on Algorand followed the steps defined by the system's architecture. First, Issuer+ RH multisignature accounts sequentially created each ASA, issuing an asset creation transaction for each one. Subsequently, the individual ASAs were transferred to their respective Collective Management Organizations (CMOs). This process occurred in

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<sup>10</sup> <https://www.mimit.gov.it/images/stories/normativa/Graduatoria-finale-progetti-Asse-II.pdf>

<sup>11</sup> <https://algorandtechnologies.com/news/siae-launches-4-million-nfts-on-algorand-for-creators>

two stages: first, through the asset opt-in transaction, whereby the CMO+RH multisignature accounts opted in to receive the asset; and second, through the actual transfer, executed via the multisignature account. Once each ASA was assigned by the RH to the corresponding CMO, the bootstrap phase was considered complete.

The total economic cost of digitizing all rights managed by SIAE on Algorand amounted to approximately \$665,000. This figure was calculated based on the minimum transaction fee of 0.001 Algo required per operation. Each creation, opt-in, and transfer of an individual asset incurs a fee to ensure the proper functioning of the system. On March 22, 2021, the day the bootstrap phase began, 1 Algo was valued at approximately \$0.82<sup>12</sup>, meaning the fee per transaction was \$0.00082. Multiplying this by the 4 million assets created yields an estimated cost of \$3,280, to which an additional \$3,280 must be added for the opt-in transactions and another \$3,280 for the transfers. Thus, total transaction fees amounted to \$9,840.

In addition to these fees, the operation required the allocation of a Minimum Balance Requirement (MBR) for the creation and holding of ASAs on Algorand. The MBR is the minimum balance of Algos that each account must maintain to support the management of its ASAs. This amount cannot be transferred or spent, as it serves to prevent spam actions and the massive creation of fake accounts or assets that would otherwise burden the blockchain's storage capacity, helping to keep the network lightweight and efficient. Each account must therefore ensure that its memory usage is

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<sup>12</sup> <https://coinmarketcap.com/it/currencies/algorand/>

backed by a real economic cost. As previously mentioned, the MBR on Algorand is 0.1 Algo per ASA, which must be allocated both for the creation of each ASA and again for the opt-in transfer. Consequently, the entire bootstrap process required a total of 800,000 Algos to be locked as MBR, corresponding to approximately \$656,000.

The overall cost of the operation thus amounted to \$665,840, a significant figure, though only about 1.48% of it was actually spent on transaction fees. The remaining amount represents locked capital, which could potentially be released upon the closure or deletion of the ASAs. It is important to note, however, that while the number of Algos required as collateral remains fixed, their monetary value is subject to volatility over time.

SENDER	DESCRIPTION	COST
Issuer+RH	Asset Create Transactions	\$3,280
CMO+RH	Asset Opt-In Transactions	\$3,280
Issuer+RH	Asset Transfer Transactions	\$3,280
	<i>TOTAL transaction fees</i>	<i>\$9,840</i>

NFT Rights	4,000,000
Algo Price	\$0,82
Algo Fee	0.001
Algo MBR	0.1

OPERATION	COST
Asset Create MBR	\$328,000
Asset Ownership MBR	\$328,000
<i>TOTAL MBR</i>	<i>\$656,000</i>

<u>Total transaction fees</u>	\$9,840
Total MBR	\$656,000
<b>TOTAL Cost</b>	<b>\$665,840</b>

**Tab 4** Cost considering the 4M tokens issued by SIAE on March 22, 2021.

Regarding the time required from the creation to the final transfer of the ASAs, it is necessary to consider the operational speed of the Algorand network, which is approximately 1,000 transactions per second (TPS). Assuming that only 50% of the network's throughput is utilized, an effective average of 500 TPS can be considered. With this processing capacity, completing the 12 million transactions required, comprising 4 million for each of the transaction types described above, would take a total of 24,000 seconds, equivalent to approximately 6 hours and 40 minutes. These processing times are entirely acceptable when compared to the performance of other permissionless blockchains during the same period.

A comprehensive evaluation of the GloC-Net platform as a long-term alternative to the centralized IPI system must demonstrate beyond technical performance its economic sustainability, including any environmental externalities, particularly in light of the growing regulatory and societal attention directed at the energy impact of blockchain-based systems.

From an economic standpoint, the GloC-Net launch phase involved the issuance of approximately four million NFTs, with total transaction fees amounting to roughly \$9,840, a remarkably low figure made possible by Algorand's minimal fee structure of 0.001 ALGO per transaction. This stands in sharp contrast to the multi-year operational costs associated with maintaining the centralized IPI system, which requires dedicated server infrastructure, database administration, manual data quality control, and bilateral reconciliation processes among CMOs. While precise cost data for the IPI

system are not publicly available, estimates drawn from large-scale enterprise database deployments suggest that annual operating expenditures for a system of comparable complexity may range from several hundred thousand to several million euros per year. Even accounting for the ongoing maintenance costs of the blockchain infrastructure, including node operation, smart contract auditing, and interface development, the blockchain-based model appears capable of delivering significant long-term cost efficiencies, particularly as transaction volumes increase and fixed platform development costs are amortized across a broader user base.

From an environmental perspective, Algorand's Pure Proof-of-Stake consensus mechanism represents a fundamentally different energy paradigm compared to Proof-of-Work systems such as Bitcoin. Algorand has been certified carbon neutral since 2021 and, according to figures published by the Algorand Foundation, the entire network operates at an estimated energy consumption of approximately 0.000008 kWh per transaction, several orders of magnitude lower than the estimated 700-900 kWh per transaction attributed to Bitcoin, or Ethereum's pre-Merge consumption of 50-100 kWh per transaction. Applying these figures to the GloC-Net launch phase, the four million transactions executed during the rights digitization stage would have consumed approximately 32 kWh in total, roughly equivalent to the energy required to power a single household appliance for a few hours. At full operational scale, assuming tens of millions of annual transactions across all participating CMOs, the cumulative energy footprint of GloC-Net would remain negligible in absolute terms. This compares

favorably not only with PoW-based blockchain alternatives, but also with the aggregate energy consumed by the centralized IPI system's data centers and the physical bilateral data exchange processes among CMOs. While the latter figures are not precisely documented in the public domain, it is well established that large-scale enterprise IT systems of comparable scope consume thousands of kWh annually for data center operations alone.

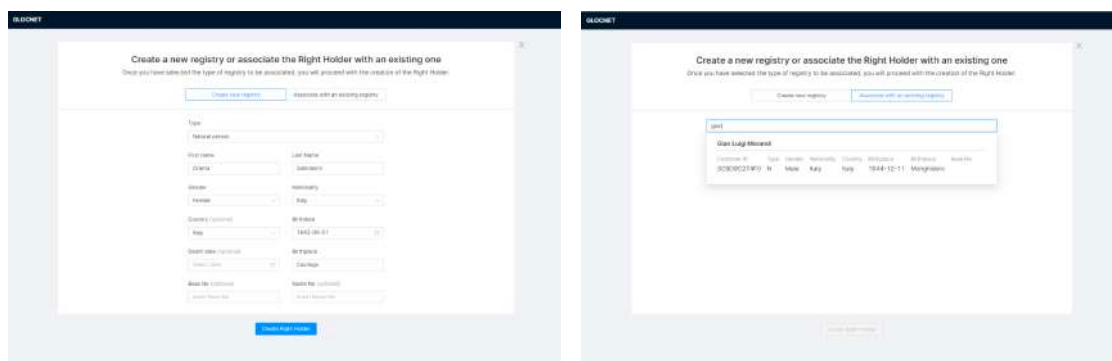
In light of the foregoing, Algorand-based copyright management compares favorably with both existing centralized systems and alternative blockchain architectures relying on energy-intensive consensus mechanisms. As sustainability criteria increasingly inform regulatory requirements for digital infrastructure, the selection of a high energy-efficiency blockchain such as Algorand constitutes not merely a technical preference, but a strategically sound and future-proof commitment.

### **4.3 GloC-Net interface**

Once the system architecture had been defined, funding secured, and the transfer of copyright initiated on the designated blockchain, development began on a user interface (UI) designed to enable artists and Collective Management Organizations (CMOs) to operate directly, through an intuitive and easily accessible platform. Despite the underlying complexity of GloC-Net's functioning, the platform's primary goal is to decentralize copyright management, ensuring that every user can access and operate within it independently. This led to the release, in July 2021, of a beta version of the

interface allowing users to manage copyright details, particularly those concerning specific agreements.

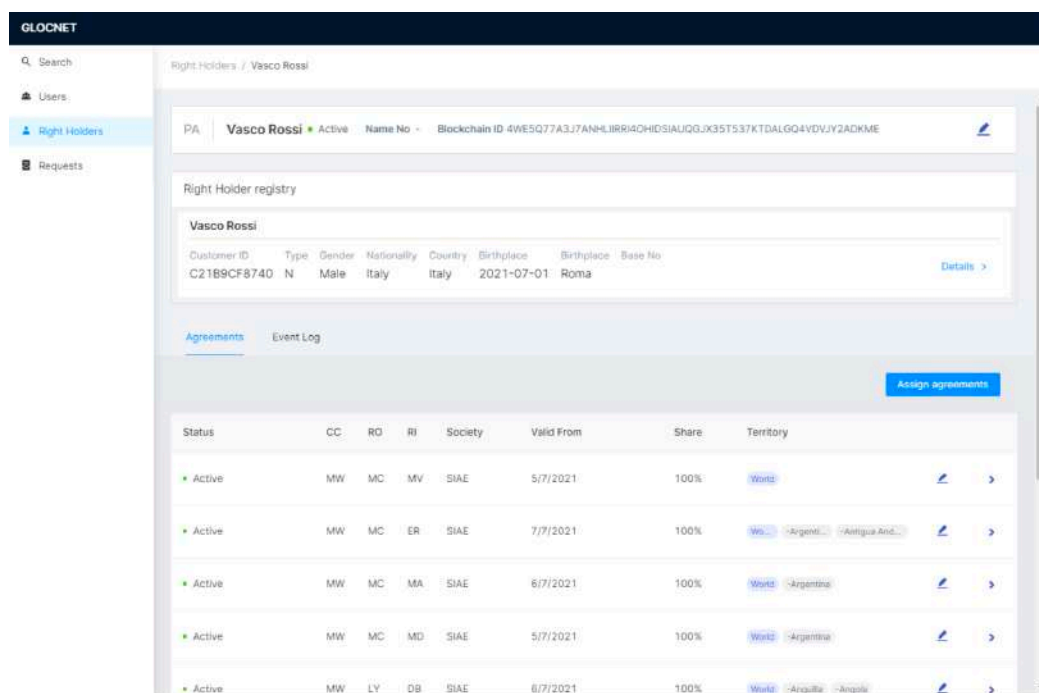
As with any other platform, the user experience (UX) begins with registration through credentials provided to each individual user to access the attribution ledger. Once logged in, the first available action on the main screen is the creation of a new information registry, allowing the user to choose the type between natural person and legal entity. The registry essentially corresponds to the RH's fields within an IPI record. Depending on the selected type, users are required to enter specific personal data: for a natural person, the mandatory fields are name (IP\_name), gender, nationality, date of birth, and place of birth; for a legal entity, only the company name is required. Optionally, users may also include the Base\_No and Name\_No from the IPI system. In addition to creating their own RH information registry, users can alternatively link an RH to an existing registry by searching among those already stored within the platform.



**Fig 9** Screen of the beta version of the interface for creating or associating a registry.

After associating a registry, the author is identified through a pseudonym (PP) that differs from the IP\_name (e.g., associating the PP “Gianni Morandi” with the given name “Gian Luigi Morandi”), and the association between the Right Holder (RH) and the registry is then confirmed. In this way, CMOs can create registries corresponding to their artists, while the artists themselves can review the information and link their pseudonyms to pre-existing registries.

On the main screen dedicated to Right Holders, it is possible to view all registered artists in a fully transparent manner, and by selecting any of them, users can easily access the complete list of “agreements” associated with that artist.



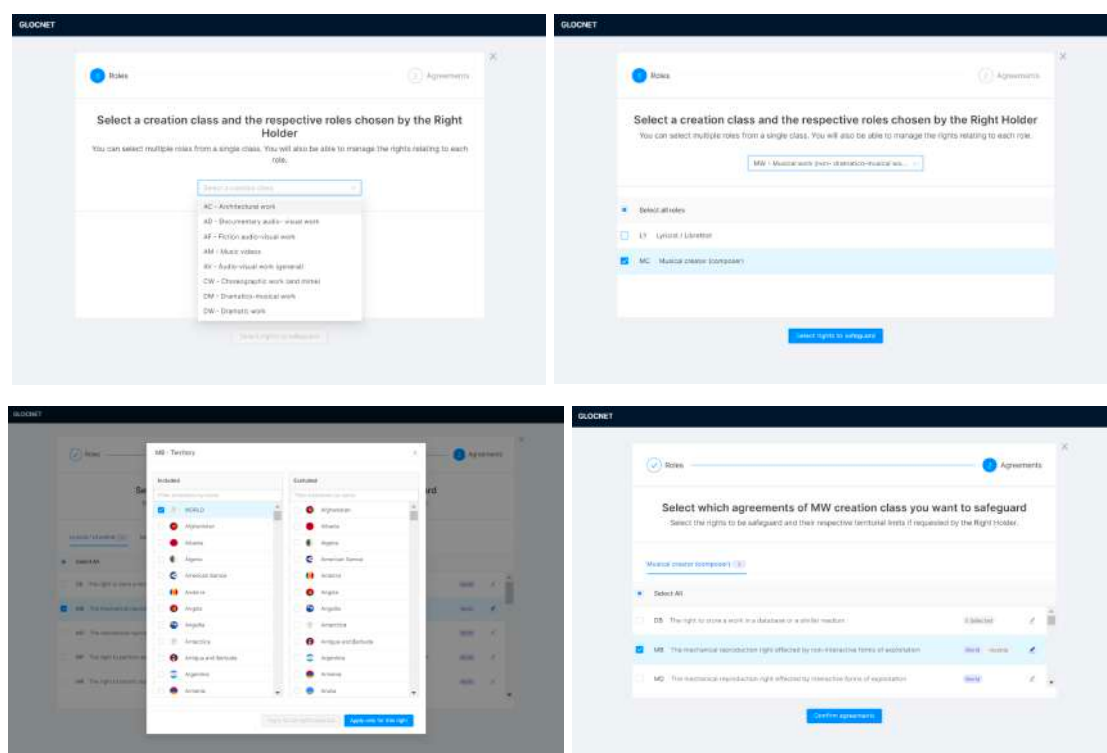
**Fig 10** Beta version of the GloC-Net interface on the “Right Holders” page with Vasco Rossi's profile selected.

In the Right Holders Agreement tab, a list of all agreements associated with a specific Right Holder (RH) is displayed. In the column-based report, users can review the status of each agreement, the type of creation class (CC), the artist's role (RO), the category of protected right (RI), the Collective Management Organization (CMO) that safeguards the agreement (Society), the date on which the agreement was created, the ownership percentage of the right, and the territory in which the agreement is effective.

To this list of agreements, CMOs can add new ones using the “assign agreements” button located at the top of the page. This action opens a window where the first required input is the type of creation class (CC). The user must choose among several classes, such as Music Videos (AM), Choreographic Work (CW), Dramatic Work (DW), and many other categories selectable from a drop-down menu. Once the CC is selected, e.g., Musical Work (MW), the next step is to specify the role (RO). In the case of MW, the RO can be either Lyricist/Librettist (LY) or Musical Creator (MC).

The process then continues with the selection of the rights to safeguard (RI). The platform provides a range of protection types corresponding to the specific CC and RO, such as Radio Broadcast Right (RB) or Mechanical Reproduction Right (MB), as well as more contemporary rights related to digitalization, such as the right to store a work in a database or a similar medium (DB). An agreement may cover multiple forms of protection, and for each RI, users can specify the territories where it is valid or excluded. For example, one may grant worldwide validity by selecting “world” while excluding individual countries.

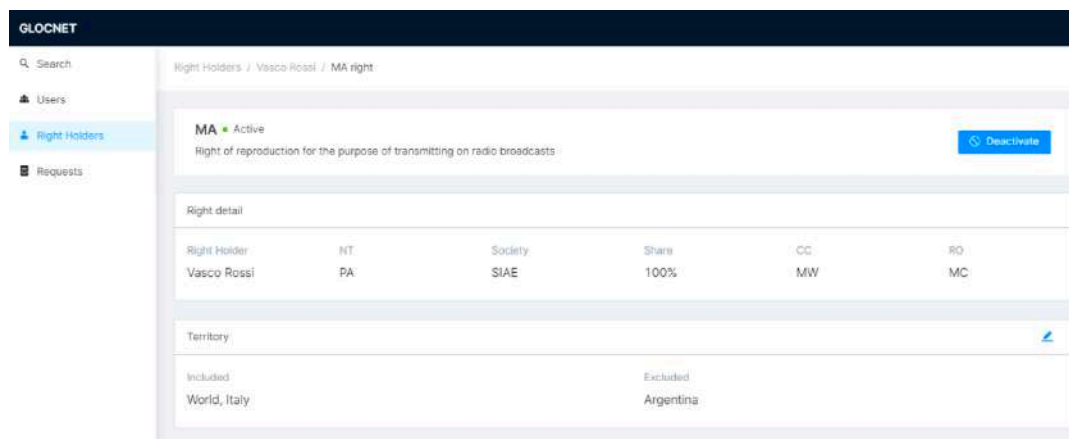
Once all RIs included in the agreement have been defined, along with their respective territorial scopes, the user can confirm to finalize the creation of a new agreement, which must then be accepted by the RH. By default, the CMO that registers the agreement is automatically assigned 100% of the ownership percentage of that right.



*Fig 11 Assign agreements process in the beta version of the interface.*

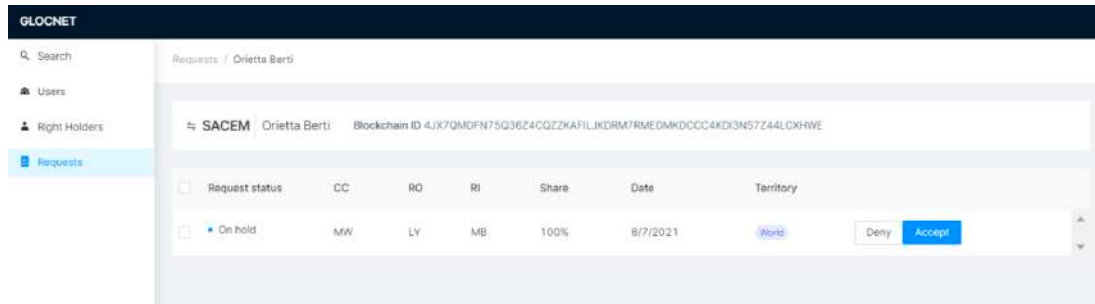
Once agreements are active, meaning they have been accepted by the Right Holder (RH), they can only be modified with respect to their validity period, territorial scope, and the ownership shares of the CMOs. In the first case, the CMO managing an agreement can access its details and use the “Deactivate” button, thereby terminating the agreement’s validity at the moment of selection. In the second case, the authorized

CMO has access to an editing tool that allows for the redefinition of the territories included in or excluded from the agreement.



*Fig 12 Details sheet for agreements in the beta version of the interface.*

Regarding the transfer of part or all of a share from one CMO to another, the latter must initiate a formal transfer request. In the agreement details, any CMO that does not currently manage the right will find, instead of the “Deactivate” button, an option labeled “Request transfer.” By proceeding with this request, the CMO confirms the RH associated with the agreement, the territories in which the agreement is valid, and the portion of the share to be transferred. The request remains valid for 30 days, during which the RH holding the right must access the dedicated “Requests” tab to either accept or reject the transfer.



*Fig 13 Beta version of the GloC-Net interface on the “Requests” page.*

In this way, the user interface (UI) faithfully reproduces the functioning of the IPI system with respect to its three core features: the creation of a new record, the reading of records associated with a specific author, and the updating or deletion of an existing record. All these operations, however, are recorded within a blockchain-based structure.

#### **4.4 Decentralisation requirements and limits of Gloc-Net**

The development of GloC-Net as a decentralized version of the IPI system must satisfy a set of requirements that can be summarized as follows:

1. The ability of a Right Holder (RH) to autonomously create and manage their own artistic rights;
2. The possibility for anyone to view the entire system state without intermediaries, thereby verifying the accuracy of individual agreements;
3. The consent of both parties to the conclusion of an individual agreement between an RH and a CMO must always be demonstrable;

4. The creation or updating of artistic rights must always occur with the explicit consent of the corresponding RH;
5. The creation or updating of an agreement must always occur with the joint consent of both the RH and the CMO;
6. The most up-to-date version of an agreement and the underlying artistic rights must always be easily readable and traceable among all entries within the system.

Concerning the requirements above, point 2 (p2) may raise potential privacy concerns. However, these concerns are unfounded, since, even though the IPI system itself is not directly accessible to the general public, the information it contains is publicly traceable through the search tools provided by individual CMOs, such as SIAE's Archivio Opere<sup>13</sup>. Therefore, the transparency implied in p2 is consistent with the information accessibility standards of the current centralized IPI system.

The requirements outlined in points 3 (p3) and 5 (p5) are fully satisfied, as the movement of an ASA on the platform requires an opt-in transaction signed by both parties via a 2-of-2 multisignature account system. The underlying process can be schematically described in four phases:

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<sup>13</sup> <https://servizionline.siae.it/en/archivioOpere>

- An RH wishing to assign an artistic right to a CMO in the form of an ASA {CC, RO, RI, TERR} requests an Issuer to generate the corresponding NFT on the Algorand mainnet;
- Through a 2-of-2 multisignature account (Issuer + RH), both the Issuer and the RH sign the creation of the digital token on the blockchain;
- The RH then reclaims ownership of the ASA via the clawback address in order to transfer it to the CMO responsible for managing the real-world protection of the artistic right. To confirm the transfer, both the RH and the CMO must enable its reception (opt-in) through a new 2-of-2 multisignature account shared between them (CMO1 + RH). Once the assignment is completed, the agreement becomes valid between the two parties according to the transaction timestamp;
- If the RH later decides to assign the ASA to another CMO, they regain control of the digital token via the clawback address and transfer it to a new 2-of-2 multisignature account (CMO2 + RH), repeating the opt-in and assignment process. The timestamp of this new transaction marks the closure of the previous agreement (Valid\_to) and the beginning of the new one (Valid\_from).

The signatures themselves serve as verifiable proof permanently recorded on the blockchain, preventing any malicious or negligent party from corrupting the platform with falsified data or from forcing a CMO to accept an ASA it does not intend to receive. Consequently, any manipulation would require the consent of both the RH and the CMO. Moreover, this design choice does not prevent the creation of multiple ASAs

on the blockchain. Should multiple ASAs representing the same right be erroneously registered, the platform will recognize as valid only the latest ASA entered on-chain.

As a result of this process, requirements point 4 (p4) and p2 are also satisfied. The RH's consent in p4 is explicitly required by the Issuer during the ASA creation phase through the multisignature account (Issuer + RH); similarly, during any update, the RH must always approve via joint signature. As discussed earlier, p2 does not raise legal issues, and the decision to employ a public blockchain such as Algorand allows unrestricted access to the entire system state.

However, challenges remain regarding points 1 (p1) and point 6 (p6). In relation to p1, due to architectural choices, RHs are not fully autonomous in creating tokens representing their artistic rights. An Issuer is always required to generate the ASA together with the RH. Although the RH participates in the generation process, they remain dependent on a trusted Issuer, thereby violating the stated condition. SIAE nonetheless acknowledged this initial centralization during the first phase of rights validation, a temporary limitation deemed acceptable for the early stages of platform development, with the long-term goal of achieving a fully decentralized model, including the creation of rights directly on the blockchain.

The Issuer's preliminary role is to verify that the ASA to be generated is correct and not already present in the attribution ledger. Should an ASA be created erroneously and conflict with an existing one, the RH's acceptance would validate the newer

representation of the artistic right, superseding previous entries. However, this implies that users seeking to verify whether an ASA is the most recent on-chain record must scan the entire blockchain, which contravenes p6.

In summary, despite the initial premises for a fully decentralized system intended to replace the IPI model, the version developed by SIAE does not yet allow right holders to autonomously create their own rights, nor does it enable the retrieval of the most up-to-date version of an artistic right without scanning the entire blockchain.

#### **4.5 Proposals for the implementation of smart contracts**

As discussed in the previous section, the issue of conflicting ASAs representing the same artistic right undermines both the ability of a Right Holder (RH) to autonomously generate ASAs on the blockchain and the ease with which artistic rights and their related agreements can be read and verified on-chain. To address these challenges, several concrete solutions based on smart contracts<sup>14</sup> have been analyzed to prevent conflicts among digital tokens and to respond to the two issues discussed above (Vitaletti & Zecchini, 2023; Della Monica et al., 2025).

In the current platform architecture, all conflicting ASAs are stored on the blockchain, with only the most recent one deemed valid. In practice, however, this approach necessitates continuous monitoring of the blockchain or scanning of all

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<sup>14</sup> Solution already envisaged as a potential issuer, but not implementable at the time of project development as Algorand did not yet support smart contracts with large computing capacities.

blocks, which translates into increased computational effort for users. The implementation of smart contracts to automatically detect potential conflicts can effectively mitigate these limitations.

Before examining specific technical approaches, it is important to clarify how the physical identities of individual RHs are digitized. In the IPI system, RHs are uniquely identified through the assignment of a Base\_No by the platform. On Algorand, by contrast, users can create as many accounts as they wish, enabling a proliferation of digital identities. In a public key cryptography system such as a blockchain, the traditional method of linking a digital identity to a physical one relies on digital certificates issued by Certification Authorities (Chadwick & Basden, 2001). Although this model conflicts with the decentralization principles that underpin blockchain technology, since it introduces a single point of failure inherent in centralized systems, it does not compromise the validity of the present case study, given that the digital identification of RHs is a foundational assumption of the project.

The process to be decentralized concerns copyright management, not RH identity verification, which is already completed prior to registration on the platform. Therefore, the issue is not that an RH's identity is verified by a third party, but rather that, once identified, the RH can autonomously and in a decentralized manner manage their artistic rights, an autonomy that marks a key distinction from the IPI system. It should be noted, however, that existing literature has proposed alternative decentralized methods for identity verification on blockchain, replacing centralized

Certification Authorities with distributed counterparts (Matsumoto & Reischuk, 2017; Yakubov et al., 2018; Qin et al., 2020).

Once this crucial point on RH identity is established, smart contract-based techniques for mitigating potential ASA conflicts can be categorized into two main approaches:

- Optimistic approach, which does not prevent the creation of conflicting ASAs but discourages it, thereby reducing the frequency of such occurrences.
- Preventive approach, which entirely prevents the creation of ASAs containing the same artistic right.

In the optimistic approach, the creation of conflicting digital tokens is not prevented but rather discouraged through the use of a smart contract that allows users to report irregularities. In this way, any user can flag conflicts to the smart contract, which, depending on its programmed logic, can delete invalid NFTs and potentially impose penalties, including economic sanctions, on malicious issuers. This approach is termed optimistic because the system is expected to reach a valid state based on the assumption of active user vigilance.

In the preventive approach, the Issuer is no longer a CMO but a smart contract itself. Only the smart contract can create new tokens, with the restriction that it cannot issue new ones that conflict with those already existing on the blockchain. This represents the highest degree of decentralization. The RH requests the creation of a new ASA

from the smart contract, which checks whether the attribution ledger already contains an ASA with the same artistic right. If no conflict is found, the smart contract adds the new ASA to the blockchain; otherwise, the request is ignored. In other words, a smart contract will create new ASAs representing RH rights only if such rights are not already registered on-chain. While this solution offers the most complete form of decentralization in copyright management, it has a significant limitation: to perform the conflict check, the smart contract must have access to all rights already represented on the blockchain. This requires substantial storage capacity and incurs significant computational costs. Thus, it becomes necessary to compress the representation of the state of the rights within local storage, where “state” refers to the set of an RH’s rights recorded in the attribution ledger, and “local storage” denotes the space used by the smart contract to store this state for each user. This problem can be addressed using either a BitMatrix or a Merkle Tree structure.

A BitMatrix is a matrix representing the state of an RH. Each element of the matrix corresponds to an artistic right defined by a tuple  $\{CC, RO, RI, TERR\}$  and holds a boolean value (true or false). If a given artistic right has already been created, the value is true; otherwise, it is false. Under this model, when an ASA is created, the smart contract checks the value of the cell corresponding to that artistic right. If the cell’s value is false, the contract proceeds with token creation and updates the value to true; otherwise, it rejects the request. If the RH later requests the deletion of an ASA, the smart contract locates the relevant cell and changes its value back to false. This solution

is simple and efficient, requiring few on-chain operations (Xu et al., 2022), but it is not sufficiently succinct, especially for a blockchain such as Algorand, which has limited local storage (2 KB per user<sup>15</sup>, corresponding to a maximum of approximately 16,000 cells if one bit per cell is used). The state is thus fully represented in storage, with all rights explicitly tracked in the saved matrix.

The alternative solution involves the use of a Merkle Tree, which allows for a more succinct representation of the state. In computer science, the Merkle Tree is a tree-based data structure in which each leaf node at the base contains the hash of a data block, e.g., the data associated with a specific artistic right. The intermediate nodes aggregate the hashes of their two leafes to generate a new hash, continuing recursively up to the Merkle root, which represents the overall hash of the entire data set. This structure is widely used in peer-to-peer networks such as blockchain systems due to its ability to efficiently and securely verify the integrity of a data set (Liu et al., 2021). In this approach, only several root hashes of different Merkle Trees are stored in local storage. Assuming that the leaves of each Merkle Tree represent combinations of the tuple {CC, RO, RI, TERR}, the RH, in order to create an ASA, must provide the smart contract with proof that the leaf corresponding to the requested artistic right currently holds a false value. For example, a musician seeking to create a right would specify Musical Work (MW) as the CC, Performing Right (PR) as the RI, Musical Creator (MC) as the RO, and request that protection be active across all global TERR. If the Merkle proof

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<sup>15</sup> <https://dev.algorand.co/concepts/smart-contracts/storage/overview/>

for MW–PR–MC–World is verified, the smart contract updates the value to true, recalculates the new root hash, stores it, and generates the requested ASA; otherwise, the request is ignored. Unlike the BitMatrix, the use of root hashes allows the assets contained in local storage to be expanded to several million, depending on the depth of the tree.

In the case where one aims to represent the entire possible set of a user’s rights, only the Merkle tree preventive solution would be applicable. Since in the IPI system from which the structure is derived, there are 16 CCs, 34 ROs, 26 RIs, and 220 TERRs (cardinality in table 5). The total possible combinations of the tuple exceed three million ( $16 \times 34 \times 26 \times 220 = 3,111,680$ ). However, in the case of the transposition of rights into ASAs by SIAE in March 2021, the average number of digital tokens per artist was approximately 42. Therefore, based on practical experience and assuming that an artist primarily requires only certain variables, like CC and RO, of their artistic rights, both solutions could be feasibly implemented.

	<b>GloC-Net</b>	<b>Optimistic Solution</b>	<b>Preventive approach: BitMatrix</b>	<b>Preventive approach: Merkle tree</b>
Implementation	Easy	Easy	Easy	Moderate
On-chain state lookup	X	Efficient	Efficient	Efficient
No conflicting NFTs	X	X	Prevention by design	Prevention by design
Storage space	-	-	~16k elements	~1.5M elements

**Table 6** Comparison among GloC-Net and different solutions of decentralization with smart contracts.

Building on the decentralization limitations identified in the case study, two different approaches were analyzed, leading to three distinct solutions based on the implementation of smart contracts. In relation to the six requirements defining the full decentralization of copyright management compared to the IPI system, the proposed solutions enhance and refine the architecture of GloC-Net.

In the case of the optimistic approach, implementation is straightforward, requires no local storage, and enables RHs to create their own ASAs directly without the involvement of any third-party issuer, thereby fulfilling requirement p1. The use of a 2-of-2 multisignature account (Issuer + RH) for digital token creation on the blockchain is no longer necessary. The incentive mechanism encourages system users to report conflicting digital tokens to a smart contract, which verifies the conflict and removes redundant tokens. Consequently, it becomes unnecessary to read the entire system, as only one version of each individual artistic right exists, thus satisfying requirement p6.

The two preventive techniques, on the other hand, retain the presence of an Issuer, although represented by a machine operating strictly according to the logic defined in its code. However, by design, they absolutely prevent the creation of duplicate ASAs. The main distinction between these two techniques lies in their per-user storage limitations, making one or the other preferable depending on the number of ASAs involved.

## **4.6 Future payments management implementation**

Despite the limitations previously discussed, some of which have been addressed in recent years through directly implementable smart contract-based solutions, the platform analyzed thus far represents a concrete and practical approach to meeting artists' needs to autonomously manage their own rights without relying entirely on a centralized third party (single point of failure). It also provides artists with greater control over their remuneration. Indeed, the next step after the decentralization of rights management would be the capacity to implement real-time economic transactions through a transparent system capable of recording each instance of use of an artistic right and the corresponding royalties owed to the right holder (RH). Among the many applications of blockchain technology, one of the most prominent and well-known is its function as a payment system through cryptocurrencies (Hashemi et al., 2020; Mohanty et al., 2022). It is therefore not unreasonable to imagine a further implementation involving decentralized remuneration for artists, whereby each transaction is traceable and compensation is credited directly to the respective RHs' digital wallets.

Once the protected right is defined and a specific amount established for the exploitation of the IPs underlying that right, every digitally traceable use thereof, according to the terms set out in the agreement, could translate into a direct, disintermediated payment to the RH via blockchain. Consider, for instance, a digital service provider (DSP) such as Spotify, which enables unlimited streaming of musical

works on its platform. Each work is protected by copyright and provides a certain economic return to the artists. Once an artistic right related to the reproduction of an RH's works is defined within a decentralized system, the RH would not only be able to monitor how often their works are reproduced, but also automatically receive all associated payments without intermediaries. This would constitute a genuine revolution in the current management of artist remuneration, which is often opaque and difficult to verify. In summary, the adoption of blockchain for the remuneration of artistic rights would yield several benefits: verifiable and direct payments to artists, reduced intermediary costs, and enhanced transparency of transactions (Yahya et Habbal, 2021; Dsouza et al., 2022).

Supporting this vision are not only the statements of the SIAE General Manager<sup>16</sup>, who from the project's inception emphasized the role of blockchain in remuneration processes, but also the action plan submitted as part of the funding proposal, which explicitly listed the "management of economic flows directly on-chain" among its objectives. Clearly, such functionality can be implemented where data flows are digital, as in the aforementioned case of DSPs, but it becomes more complex in situations where information must be translated from the physical world into digital form. Remaining within the domain of musical performance, consider a public event where songs by various artists are played before an audience without any tracking or monitoring. In such cases, individual IPs must be recognized and digitally recorded in

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<sup>16</sup> [https://www.ansa.it/sito/notizie/cultura/musica/2021/03/24/-siae-e-la-sfida-digitale-i-diritti-su-una-blockchain\\_d80848c5-2b9a-4c71-a7b6-158d3917f421.html](https://www.ansa.it/sito/notizie/cultura/musica/2021/03/24/-siae-e-la-sfida-digitale-i-diritti-su-una-blockchain_d80848c5-2b9a-4c71-a7b6-158d3917f421.html)

order to calculate and distribute royalties to the RHs at a later stage. This entire process is currently managed by SIAE, and by other collective management organizations (CMOs) worldwide, through a system based on the “Musical Program,” also known as the “borderò”.

The borderò is a paper or online form that must be completed whenever live music is performed or copyrighted works managed by a CMO are publicly played. Its purpose is to have the event director declare which works were performed and to indicate the authors, composers, and publishers qualifying as RHs. However, this system presents significant weaknesses and inaccuracies concerning the information on performed works. Completion of the document, later processed by SIAE for royalty distribution, is the responsibility of a third party who may, either intentionally or unintentionally, report incorrect or incomplete information about the protected works performed. Consider, for example, a nightclub event where the disc jockey (dj), acting as the responsible party, must at the end of the performance manually list all the tracks played during the night without any form of control or verification. This example can be extended to virtually all types of live performances, illustrating the distortions and limitations produced by a system in which the recognition of IPs depends on a single centralized actor. Moreover, the time lapse between form completion and the actual royalty payment to RHs further exacerbates inefficiencies.

To address the need for an automated process that ensures a clear and transparent digital translation of real-world data, SIAE’s objectives also included the development

of a proof-of-concept (PoC) smart device capable of detecting and recognizing audio tracks and linking them in real time to the corresponding artistic right recorded on the attribution ledger. This PoC device was intended to replace the borderò and achieve a recognition accuracy of approximately 70%, based on applications such as Shazam (Wang, 2006). Furthermore, its infrastructure was designed to exploit the 5G network provided by Wind S.p.A., thereby integrating this technology as well. The IoT device was to be tested over the 5G network to assess the low-latency transmission of tracks performed in entertainment contexts, such as a dj live set, to a program capable of recognizing them using AI-based techniques. Once the track was identified, the device would then interact, via 5G, with the attribution ledger to associate it with the corresponding artistic right. In theory, this would have enabled the automatic distribution of royalties derived from the detected use of IPs through a blockchain-based infrastructure.

Unfortunately, several factors coincided with the start of the project in 2020, most notably the escalation of a global pandemic and the resulting need, given limited resources, to prioritize the development of the decentralized rights management platform. The funding program had allocated a total of €5 million to be divided among six winning projects. The resulting amount was sufficient only to cover the development of GloC-Net, the core of the initiative, and the initial creation of NFTs, as previously discussed in the economic analysis. Consequently, development proceeded directly to implementing the attribution ledger on Algorand, bypassing the

planned in-lab testing phase and postponing all aspects related to IP recognition systems and royalty payments to RHs.

The absence of the aforementioned hardware and of any direct remuneration system as initially envisioned means that GloC-Net currently stands as a ready-to-use platform for transparent and verifiable decentralized rights management, yet remains significantly limited by its inability to apply this innovation to the most critical dimension: the economic one. As a result, the platform's practical utility, and the RHs' incentive to adopt it, are undermined, since the benefits in terms of royalties remain tied to a centralized, fully intermediated system managed by CMOs, DSPs, and major record labels. Unfortunately, the architecture, though painstakingly designed and developed, is effectively reduced to allowing an artist to digitally record their copyright semi-autonomously and delegate its management to a CMO, without any means of influencing the exploitation of that digitized right.

For these reasons, to render the platform fully functional, it is essential at least to integrate into GloC-Net the records of payments made by SIAE to RHs based on the rights present therein. This would represent a first step toward transparency and a necessary precursor to future integration of direct remuneration management. In parallel, it will be crucial to explore existing smart devices capable of replacing the current outdated borderò system (Turchet et al., 2018; Sahbudin et al., 2019).

## 5. Conclusion

The case study analyzed represents an example of how a complete shift in perspective can be envisioned by redefining the roles and structures of a market that has traditionally remained relatively unchanged in its dynamics, despite the progress of digitalization. It has been observed that technological advancements in the music industry have not only transformed the ways in which works are consumed but have also led to the concentration of power and financial flows in the hands of a few Majors and DSPs. This centralization is also evident in the management of copyright protection, where CMOs act as intermediaries between artists and distributors, controlling the ways in which artistic rights are used and collecting the corresponding royalties.

Although this system has functioned effectively so far, it is not without criticism and growing concerns among artists, such as the lack of direct control over their rights and the limited transparency and traceability of remuneration related to the exploitation of IPs.

Within this context, the blockchain-based solution proposed by SIAE fits particularly well. The decentralized platform GloC-Net has been fully developed, featuring an architecture that allows RHs to directly manage their artistic rights. While certain limitations still exist in the process of creating digital versions of rights, these can now be overcome through the implementation of smart contracts, which enable

artists to exercise full control even during the initial stages. In this way, the Italian CMO introduces a paradigm shift aimed at responding to the unstoppable innovation in both processes and products.

SIAE thus redefines itself: from a traditional intermediary to a provider of services linked to a blockchain-based technological infrastructure, promoting a more transparent and user-centric management model. The organization will need to provide an intuitive interface for members who wish to autonomously manage their rights. Looking ahead, SIAE envisions that even the remuneration process for works could be delegated to decentralized technology. This perspective aligns with SIAE's nature as a public, non-profit entity whose mission is to ensure the greatest possible benefits for its associated artists.

Nevertheless, the full realization of this vision will require the broad participation of all stakeholders. Until such widespread adoption is achieved, the intermediary role will continue to hold relevance. SIAE will therefore persist in acting as an intermediary for those who do not wish, or are not able, to operate independently, in accordance with its current institutional mission.

Unfortunately, the ambition to become an international pioneer has faced significant challenges due to the need for global cooperation among various CMOs. The Italian launch did not receive an enthusiastic response from other organizations, starting with European CMOs that refused to abandon the IPI system in favor of greater

decentralization. This reluctance has significantly slowed the dissemination and development of GloC-Net, which was originally designed to have a global scope and required extensive adoption by CMOs worldwide to achieve genuine decentralization for artists.

Within the ever-evolving landscape of blockchain-based initiatives in the music and copyright sector, it is possible to compare GloC-Net with Audius and OMI, the other two projects already cited in the literature review, and to contrast their respective approaches with that of SIAE. Although all three share the common objective of addressing inefficiencies in music rights management through technological innovation, they differ substantially in terms of scope, governance model, and stakeholders involved.

Audius represents a bottom-up, consumer-oriented revolution. It bypasses traditional intermediaries entirely, enabling artists to publish and monetize music directly on a decentralized platform. However, it does not interface with the formal copyright management infrastructure administered by CMOs. It neither addresses the complex international framework of bilateral agreements among rights management organizations, nor does it provide a mechanism for the registration of copyrights in a legally recognized manner across jurisdictions. In this respect, Audius and GloC-Net operate at different levels of the ecosystem: the former competes with streaming platforms and record labels, while the latter targets the interoperability layer between CMOs themselves. GloC-Net is not conceived as a consumer-facing platform, but

rather as a professional infrastructure for the registration and transfer of rights — designed to innovate, rather than supplant, the existing system.

OMI, on the other hand, is more closely aligned with GloC-Net in its institutional ambitions, as it seeks to establish open-source standards for the music industry by engaging CMOs, major record labels, and streaming platforms. Nevertheless, OMI operates primarily as a standard-setting and API-design body rather than as an operational platform. It does not directly engage in the tokenization of rights or in the on-chain recording of transactions, but instead provides the architectural blueprint for others to do so. GloC-Net, by contrast, has moved beyond the design phase and has already completed the on-chain registration of approximately four million copyright tokens on a live public blockchain. This execution-centered approach constitutes a distinctive contribution: SIAE has not merely proposed a technical standard, but has demonstrated that large-scale blockchain-based copyright management is operationally feasible within an institutional CMO context. In this regard, GloC-Net represents a more advanced stage of implementation than either Audius, which bypasses CMOs altogether, or OMI, which remains primarily at the level of standard-setting and prototyping. The primary challenge that GloC-Net now faces is not technical but institutional: achieving the multilateral CMOs adoption that would transform a single-country proof of concept into a genuinely global copyright infrastructure.

In fact its functionalities in copyright management would have limited utility if artists were unable to perform one of their primary activities, modifying the framework that governs their rights, since, at present, SIAE remains the only organization that has joined the initiative and digitally represented agreements with its artists. Consequently, the project was placed on hold shortly after launch, awaiting either greater awareness among other CMOs regarding decentralization or competitive pressure from alternative players offering decentralized solutions attractive to artists. Only the participation of a significant number of CMOs could create a truly global network capable of radically transforming the management of copyright.

The present study adopts a single case study approach centered on SIAE's GloC-Net. This methodological choice proved particularly well-suited to the exploratory and in-depth nature of the inquiry, enabling a detailed analysis of the platform's architecture, governance model, and implementation challenges. Nevertheless, it also entails inherent limitations with respect to the generalizability of the findings.

SIAE is a distinctive organization in several respects: it is one of the oldest and largest CMOs in Europe, it operates within a specific Italian legal and institutional context, and it has benefited from public funding, which has provided both financial resources and research partner that would not be available to most CMOs in other jurisdictions. These contextual factors may have enabled a level of investment and technical sophistication in the GloC-Net project that smaller or less institutionally established CMOs could not easily replicate. Accordingly, the findings of this study

should be understood as analytical rather than statistical generalizations (Flyvbjerg, 2006). They do not imply that any CMO in any jurisdiction would achieve identical outcomes, but rather that the technical architecture developed by SIAE offers a replicable conceptual model and a validated proof of concept for blockchain-based copyright management.

Furthermore, several conditions govern the adoption of the GloC-Net model by other CMOs and jurisdictions. First, the regulatory framework of the adopting jurisdiction must permit the recognition of on-chain records as legally valid evidence of copyright ownership and bilateral agreements. Second, the adopting CMO must possess sufficient in-house technical capabilities, or have access to qualified external partners. Where such conditions are met, the GloC-Net architecture offers a model that is adaptable to different national copyright systems without requiring fundamental redesign. Future research involving comparative case studies across multiple CMOs in diverse jurisdictions would significantly strengthen the evidentiary base and enable a more systematic assessment of which countries present the enabling conditions, both technical and institutional, for blockchain-based copyright management.

Despite these conditions and the lack of participation from other CMOs, the market potential of the project remains substantial. SIAE has successfully created a fully functional platform operating on Algorand, a permissionless blockchain, and has established an effective mechanism for representing rights through the issuance of unique digital tokens. This process could be entirely decentralized through the use of

smart contracts. While the project and the present analysis focus exclusively on copyright management, the underlying architecture could, with suitable adaptations, be applied to the decentralization of other sectors.

A notable example is the management of the “Made in Italy” brand, where producers could certify the geographical origin and quality of their goods, whether agricultural or industrial. The process would be analogous: instead of registering an artistic right, a trademark would be recorded. This and many other potential applications could give new impetus to a platform that holds considerable promise for fostering decentralization across traditionally centralized sectors.

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