

# Music Metadata Management: Challenges and Solutions in the Digital Music Industry

Iason Christofilakis

*Vrije Universiteit Amsterdam*

Amsterdam, The Netherlands

i.christofilakis@student.vu.nl

Supervisor: Dr. Jaap Gordijn

*Vrije Universiteit Amsterdam*

Amsterdam, The Netherlands

j.gordijn@vu.nl

**Abstract**—This report examines the persistent challenges within the music industry concerning the efficient and equitable management of metadata. Stakeholders acknowledge the critical role of metadata for identification, licensing, and royalty distribution in the digital age, yet inconsistencies, fragmentation, and quality issues persist. This literature review explores the multi-faceted challenges of music metadata management, drawing upon key publications in the field. It identifies inconsistent and incomplete data, data silos and lack of interoperability, complex rights management and licensing issues, legacy systems and technological limitations, and the absence of standardized schemas and vocabularies as major hurdles. The impact of these challenges on various stakeholders, including artists, rights holders, CMOs, and DSPs, is analyzed. Proposed and implemented solutions, ranging from standardization efforts and unique identifiers to blockchain technology and AI, are reviewed, alongside relevant case studies. The discussion synthesizes these findings, emphasizing the critical need for enhanced collaboration, governance, and a holistic approach to metadata management. The report concludes by offering recommendations for future directions aimed at addressing the metadata management challenges and unlocking the full potential of digital music information.

## I. INTRODUCTION

### A. The Transition to Digital Music and the Importance of Metadata

The music industry has undergone a significant transformation with the shift from physical to digital music consumption [1]. This transition, while offering unprecedented opportunities for sharing and access, has also amplified the critical importance of metadata, the “data about data” that underpins the entire digital music ecosystem [2, p. 76]. Metadata, encompassing descriptive, administrative, structural, rights-related, and use-related information, is no longer merely a background element; it has become essential for the very functioning of the industry [3].

In digital music systems, metadata serves many essential functions. For users, metadata facilitates music discovery and retrieval, enabling efficient searches, personalized recommendations, and seamless organization of vast digital libraries [4, p. 3]. For rights holders, accurate and comprehensive metadata is paramount for ensuring proper attribution and compensation, as it forms the basis for licensing and royalty distribution [5]. For businesses, metadata drives efficient operations, informing

licensing agreements, usage reporting, and data analytics [3, p. 34].

However, despite its critical importance, the music industry continues to address significant technical and operational challenges in metadata management. Inconsistent, incomplete, and inaccurate metadata affect the digital music landscape, impacting interoperability, operational efficiency, and the distribution of revenue [5]. As Morris observes, the migration to digital music has created a metadata “black hole”, where the contextual information previously available in physical media needs to be reconstructed in digital form [6]. The current state of metadata management, characterized by non-standardized practices and fragmented repositories, presents ongoing challenges for the industry.

This literature study aims to analyze these metadata management practices in depth, examining the key challenges, their impact on various stakeholders, and potential solutions. By synthesizing existing research, we seek to provide a comprehensive overview of the music metadata landscape and to identify pathways towards more efficient, transparent, and equitable metadata management practices.

### B. Defining “Music Metadata” for this Study

For the purpose of this study, “music metadata” will primarily refer to *descriptive metadata* [4, p. 11]. This encompasses factual information about musical works, such as artist names, song titles, album details, genres, and release dates. While other types of metadata, including *technical metadata* (file formats, bit rates), *administrative metadata* (rights management information, licensing details), *structural metadata* (compositional structure), and *use metadata* (user ratings, play counts), are acknowledged as important, the primary focus will remain on descriptive metadata and its role in the challenges and opportunities discussed in this review.

It is also crucial to understand the concept of *levels of abstraction* in music metadata [3, p. 15]. Following the FRBR (Functional Requirements for Bibliographic Records) model, music metadata can be categorized across different levels of abstraction, including:

- *Work*: The abstract musical creation, the intellectual property itself (e.g., Beethoven’s 5th Symphony).

- *Expression*: The specific realization of a work, such as a musical score or a particular performance.
- *Manifestation*: The physical or digital embodiment of an expression, such as a CD or a digital audio file.
- *Item*: A specific copy of a manifestation (e.g., a particular CD in a library collection).

Understanding these levels of abstraction is essential for comprehending the complexities of music metadata management, particularly in relation to rights management and licensing, where different rights may apply to different levels of a musical work. Furthermore, this study will explore the challenges around the integration of key identifiers in the music industry, such as the International Standard Work Code (ISWC), the International Standard Recording Code (ISRC), and the International Standard Name Identifier (ISNI), and the difficulties in creating a cohesive system that effectively links these identifiers across disparate databases and platforms.

### C. Study Overview

This literature review provides a structured analysis of music metadata management. Section II examines the historical context of music metadata, tracing its evolution from analog to digital formats. Section III analyzes the current technical and operational challenges in metadata handling, including data inconsistencies, system integration issues, rights management complexities, and standardization needs. Section IV evaluates the impact of these challenges on various stakeholders. Section V reviews existing and proposed solutions, from standardization initiatives to emerging technologies. Section VI synthesizes these findings, emphasizing opportunities for enhanced collaboration and systematic improvement. Section VII concludes with recommendations for future development.

## II. HISTORICAL CONTEXT: FROM ANALOG TO DIGITAL METADATA

### A. Pre-Digital Metadata Practices

Even in the pre-digital era, metadata, though not explicitly termed as such, played a crucial role in the music industry. Miller explains that metadata in its broadest sense can be traced back to annotations on sheet music and album covers, liner notes, and physical indexing systems in record stores and libraries [4, p. 7]. These paratexts, as Morris terms them, served to contextualize music, providing essential information for identification, categorization, and access [6].

Sheet music annotations, for instance, provided basic metadata such as composer, title, and sometimes performer information. Album covers and liner notes offered richer contextual information, including artwork, lyrics, artist biographies, and production details. Physical indexing systems in record stores and libraries, while limited in scope, provided a basic form of metadata organization, allowing users to browse and search for music based on genre, artist name, or album title.

However, these pre-digital metadata practices were primarily physical, localized, and often non-standardized. Information was typically confined to the physical object itself (the sheet music, the album cover) and was not easily transferable

or interoperable between different systems. The lack of standardized formats and vocabularies led to inconsistencies and limitations in data sharing and reuse.

### B. The CD Era: Early Digital Metadata

The advent of the Compact Disc (CD) in the 1980s presented an opportunity for digital metadata integration in the music industry. Velluci points out that the CD format had the capacity to embed metadata directly into the digital medium. However, this capability remained largely unexplored due to a lack of industry-wide standards and a focus on audio quality over data enrichment [7].

The CD-Text standard, introduced later, represented an attempt to address metadata integration, but faced adoption challenges and backward compatibility limitations [3, p. 17]. Consequently, the CD era was characterized by limited descriptive information in the digital format itself.

In response to these limitations, user-driven solutions like Cddb (Compact Disc Database) emerged [6]. Cddb, and later Gracenote, relied on users to contribute metadata information for CDs, creating a crowdsourced database of album and track data. While innovative for its time, Cddb faced accuracy and consistency challenges due to its reliance on user-generated content. Nevertheless, it represented an important step in recognizing the significance of digital metadata in the music industry.

### C. The MP3 and early Digital Era

The rise of the MP3 format and file-sharing services like Napster in the late 1990s further transformed the music metadata landscape. Morris observes that the migration from CDs to MP3 files often resulted in the stripping of metadata, exacerbating the “metadata vacuum” of the CD era [6].

MP3 files, unlike CDs, were easily shared and distributed online, but they lacked the contextualizing information of physical media. This led to the emergence of ID3 tags, a user-driven solution for embedding metadata directly into MP3 files [6]. ID3 tags allowed users to add basic metadata such as artist name, song title, and album title to their digital music files, providing a basic framework for metadata management in the decentralized world of file-sharing.

However, ID3 tags, while widely adopted, suffered from inconsistencies and lack of standardization. Different users employed different tagging conventions, leading to fragmented and unreliable metadata across the digital music ecosystem. The early attempts to monetize digital music in this era were further complicated by metadata management challenges, as the lack of accurate and consistent data made it difficult to track usage and distribute royalties effectively.

### D. The Rise of Streaming and the Metadata Imperative

The advent of music streaming services in the 2000s and 2010s, represented by platforms like Spotify and Apple Music, has fundamentally reshaped the music industry and intensified the need for robust metadata management [5]. As music consumption shifted from ownership to access, metadata became even more critical for:

- *Discovery and Recommendation*: Streaming services rely heavily on metadata to power their recommendation algorithms and search functions, guiding users through vast music libraries and personalizing their listening experiences. As Eriksson points out, metadata became a key component in the “algorithmic knowledge production” of companies like The Echo Nest (now part of Spotify), shaping user experiences and driving music consumption [8].
- *Automated Playlist Generation*: Metadata enables the automated creation of playlists based on genre, mood, artist similarity, and other criteria, further enhancing user discovery and engagement [8].
- *Rights Management and Royalty Distribution*: Accurate and comprehensive metadata is paramount for ensuring that royalties are correctly attributed and distributed to the appropriate rights holders in the complex streaming ecosystem. Elton emphasizes that standardized identifiers and electronic data interchange rules are essential for efficient and transparent royalty processing [9].
- *User Experience*: Metadata enriches the user experience by providing contextual information about artists, songs, and albums, enhancing engagement and understanding. As Miller argues, metadata is key to providing “intellectual access” to digital collections, making them findable, identifiable, and ultimately more valuable to users [4, p. 10].

The rise of streaming services has thus transformed metadata from a background element to a central pillar of the music industry. However, the metadata management challenges inherited from previous eras, characterized by inconsistencies, fragmentation, and a lack of standardization, have become even more evident in the streaming age, creating significant operational and business challenges for all stakeholders.

### III. KEY CHALLENGES IN HANDLING MUSIC METADATA

#### A. Inconsistent and Incomplete Metadata

One of the most pervasive challenges in the music industry is the widespread inconsistency and incompleteness of metadata. Lefever identifies in [5] that the reasons for incomplete or incorrect metadata are “the lack of properly assigned metadata, of interoperability, and of authoritative sources”. This issue stems from a variety of factors, including:

- *Human Error*: Manual data entry, a common practice in many parts of the music industry, is prone to human error, leading to typos, misspellings, and inaccuracies in metadata records. Lefever observes in [5] that metadata should be “correctly and permanently assigned to as many works as possible”, but in practice, this is often hampered by human error and inconsistent data entry practices.
- *Lack of Standardization*: The absence of universally adopted metadata schemas and vocabularies results in different organizations and platforms using different metadata systems, leading to inconsistencies in data structure and content. As Smith and Schirling highlight in [10],

“uniform formats are important to promote the availability of accurate and comprehensive information on works”, but in practice, various entities often implement different metadata systems, hindering interoperability and data exchange.

- *Legacy Data*: A significant portion of music metadata originates from legacy catalogs and databases, often created in the analog era or early digital age with less emphasis on data quality and consistency. Lyons et al. point out in [2] that shortcomings in the digitization of analogue content and lack of information in cases of orphan works or unsettled copyright heritage cases contribute to incomplete and inaccurate metadata.
- *Data Stripping*: Metadata can also be intentionally or unintentionally removed from digital music files during distribution or exchange, further contributing to data incompleteness. As Lefever highlights in [5], the phenomenon of “data-stripping”, where metadata is removed from images on news websites, noting that “97% of images on news websites are stripped of their credit metadata”.

The consequences of inconsistent and incomplete metadata are far-reaching. As Berger and Radauer found in [11], missing metadata in 10 to 50% of music tracks leads to “additional administrative costs of at least 50 million euros per year for the EU recorded music industry and possibly a licensing volume decrease of 10-50%”. Moreover, inaccurate metadata can cause delays in royalty payments, missed licensing opportunities, and a lack of recognition for artists and songwriters.

#### B. Data Silos and Lack of Interoperability

The fragmented nature of the music metadata landscape, characterized by numerous proprietary databases and a lack of standardized exchange protocols, has led to the creation of data silos and a significant lack of interoperability. Hardjono et al. argue in [12] that an “open and scalable music metadata layer” is needed to overcome these silos and facilitate data sharing and exchange across the industry.

The lack of interoperability stems from several factors:

- *Proprietary Databases*: Many music metadata providers, including Gracenote, AllMusic, and some CMOs, maintain proprietary databases with limited or restricted access. This creates data silos and hinders data sharing and exchange between different organizations. As Morris illustrates in [6], Escient’s acquisition of CDDB and its subsequent licensing restrictions demonstrate the trend towards proprietary control of music metadata.
- *Divergent Data Schemas and Vocabularies*: Different organizations and platforms often use various data schemas and vocabularies, making data integration and exchange challenging. Hardjono et al. stress in [12] the importance of standardized import and export data formats that retain digital signatures to ensure the integrity and validity of metadata files during data exchange.
- *Lack of Standardized APIs*: The absence of standardized Application Programming Interfaces (APIs) further

hinders data exchange between different systems. While some metadata providers offer APIs, these are often proprietary and lack common protocols, making it difficult for applications to access and integrate data from multiple sources seamlessly. As Hardjono et al. emphasize in [12], the lack of standardized APIs is a significant barrier to achieving interoperability in the music metadata ecosystem.

The consequences of data silos and lack of interoperability are significant. Data duplication and conflict, increased administrative costs, and hindered innovation are just some of the challenges stemming from this fragmentation. As Lefever argues in [5], the lack of interoperability “hampers the efficiency of metadata use”, creating a “risk of losing metadata when moving works between different platforms or services”.

### C. Rights Management and Licensing Issues

The complexity of music rights management and licensing further complicates the challenges of music metadata handling. As Elton explains in [9], music rights involve a complex web of ownership and usage rights, encompassing composition rights, sound recording rights, performing rights, mechanical rights, and synchronization rights, each with its own set of rules and regulations.

This complexity creates significant challenges for metadata management:

- *Multiple Rights Holders:* A single musical work can have multiple rights holders, including songwriters, publishers, performers, and record labels, each with their own share of ownership and entitlement to royalties. Accurately identifying and tracking these multiple rights holders and their respective shares is a complex metadata management task. As Hadziarapovic et al. note in [13], the decentralized nature of rights ownership and the lack of a unified database make it difficult to ensure accurate and equitable royalty distribution.
- *Territorial Licensing:* Music rights are often licensed on a territorial basis, with different CMOs and licensing agreements applicable to different countries and regions. Managing these territorial variations and ensuring accurate royalty distribution across multiple territories further complicates metadata management. As highlighted in the EU’s “Music 2025” report [2, p. 31], the complex web of territorial licensing schemes creates significant challenges in data management, leading to “distorted, diverted, delayed and diluted” revenues for creators.
- *Lack of Transparency:* The lack of transparency in licensing agreements and royalty distribution processes further hinders effective metadata management. NDAs and proprietary systems often obscure licensing terms and royalty calculations, making it difficult for artists and songwriters to understand how their music is being used and whether they are being fairly compensated. As Lefever argues in [5], the lack of transparency in licensing processes “impairs the transparency of licensing

processes” and can lead to missed licensing and business opportunities.

These rights management and licensing complexities, coupled with the inherent challenges of metadata inconsistency and incompleteness, create significant obstacles that hinder efficient and equitable royalty distribution and undermine trust in the music industry. In [14], Torbensen argues that the music industry’s lag in digital transformation has led to inconsistent and incomplete metadata, causing delays in royalty payouts and complex licensing structures.

### D. Legacy Systems and Technological Limitations

The music industry’s reliance on legacy systems and outdated technologies further contributes to the challenges in managing music metadata. As Hadziarapovic et al. note in [13], CMOs often operate with “monolithic systems” that are based on legacy software and are ill-equipped to handle the demands of the digital age.

These legacy systems often suffer from several limitations:

- *Outdated Technology:* Many legacy systems are built on outdated technologies that are not designed to handle the volume, velocity, and variety of data generated by digital music services. Lefever points out in [5] that the increased data exchange and the rapid growth in data volume in the digital era have resulted in an “unprecedented level of complexity in data management”, which legacy systems are poorly equipped to address.
- *Manual Processes:* Many metadata management processes in the music industry still rely on manual data entry, reconciliation, and distribution, which are time-consuming, error-prone, and inefficient. Lefever mentions in [14] that various practical and technical problems complicate metadata management, including the use of different publishing channels and changes in the ownership of rights, which are often handled manually.
- *Limited Scalability and Flexibility:* Legacy systems often lack the scalability and flexibility to adapt to the evolving needs of the digital music industry. They are often rigid and inflexible, making it difficult to implement new data schemas, integrate new data sources, or adapt to changing business models.

These technological limitations hinder efficient metadata management, contribute to data inconsistencies and incompleteness, and therefore impede innovation in the music industry, and continue to pose significant legacy challenges that must be addressed [15].

### E. Lack of Standardized Schemas and Vocabularies

The absence of a universally accepted metadata schema and standardized vocabularies is a fundamental challenge hindering interoperability and efficient data exchange in the music industry. Vellucci emphasizes in [7] that metadata standards are essential for ensuring system interoperability and facilitating data sharing.

The lack of standardization manifests itself in several ways:

- *Different Element Sets:* Different organizations and platforms use different sets of metadata elements to describe musical works, leading to inconsistencies in data structure and content. As Lefever observes in [5], “in practice different actors often apply different metadata systems”, hindering data integration and exchange.
- *Inconsistent Vocabularies:* Even when using the same metadata elements, different organizations often use different vocabularies and controlled terms to describe the same concepts, further exacerbating interoperability issues. As Lisena et al. emphasize in [16], the importance of using controlled vocabularies to manage the complexity of music metadata, noting that these vocabularies help reconcile different labels and ensure consistency in data representation.
- *Limited Semantic Expressivity:* Many existing metadata schemas lack the semantic expressivity to capture the full complexity of music metadata, particularly in relation to musical works, performances, and relationships between entities. As de Berardinis et al. argue in [17], a “flexible semantic model” is needed to overcome the limitations of existing schemas and to enable richer and more nuanced descriptions of music metadata.

The lack of standardized schemas and vocabularies hinders data integration, creates inconsistencies in data interpretation, and impedes the development of efficient and interoperable music metadata systems. As Smith emphasizes in [10], metadata standards are crucial for “unlocking the value of multimedia data”, but the lack of standardization in the music industry continues to hamper progress in this area.

#### IV. IMPACT ON STAKEHOLDERS

##### A. Artists and Songwriters

The challenges of music metadata management have a direct and significant impact on artists and songwriters, primarily in terms of financial losses and lack of recognition.

- *Unpaid Royalties:* Missing, incomplete, or inaccurate metadata is a major cause of unpaid royalties for artists and songwriters. As Hadziarapovic et al. note in [13], the lack of accurate and consistent metadata hinders efficient royalty distribution, leading to a “black box” of unclaimed royalties. Berger and Radauer estimate in [11] that metadata issues result in “a licensing volume decrease of 10-50%” for the music industry, directly impacting artists’ earnings.
- *Lack of Recognition and Attribution:* Inaccurate metadata can also lead to a lack of recognition and attribution for artists and songwriters. When metadata is incomplete or incorrect, it becomes difficult to properly identify and credit creators, hindering their professional recognition and career advancement. In [5], Lefever argues that “lack of recognition of authors and performers” is a significant consequence of inaccurate metadata, as “authors and performers are not likely to get proper attribution if data to identify works and authors is not accessible”.

- *Administrative Burden:* Independent artists and songwriters, who often lack the resources and infrastructure of major labels and publishers, bear a disproportionate burden in managing their own metadata and ensuring accurate royalty collection. As Lyons et al. point out in [2, p. 13], the lack of awareness and understanding of metadata management among creators further exacerbates these challenges.
- *Mistrust and Frustration:* The lack of transparency and control over data, coupled with the perception of unfair royalty distribution, has created widespread mistrust and frustration among artists and songwriters. As Anderton and Hannam note in [18, p. 51-57], the current system is often perceived as favoring labels and publishers over creators, leading to a sense of inequity and disempowerment.

##### B. Rights Holders (Publishers and Labels)

Publishers and labels, as key rights holders in the music industry, also bear a significant burden due to music metadata challenges.

- *Increased Administrative Costs:* Correcting and reconciling metadata errors, tracking down missing information, and resolving licensing disputes all contribute to increased administrative costs for publishers and labels. As discussed in the previous section, these administrative costs are substantial, with research showing they amount to millions of euros annually for the EU recorded music industry alone, directly impacting the bottom line of rights holders [11].
- *Revenue Losses:* Inaccurate metadata can lead to revenue losses for publishers and labels due to underreporting of usage, missed licensing opportunities, and delays in royalty collection. According to Lefever in [5], “poor identification of content due to missing or erroneous metadata will cause missing royalty payments or other revenue streams for rightsholders that remain unidentified”.
- *Operational Inefficiencies:* The fragmented and siloed nature of music metadata systems creates operational inefficiencies for publishers and labels, hindering their ability to manage their catalogs effectively, track usage data, and streamline licensing processes. According to an interviewee in EU’s “Music 2025” and key music industry stakeholder, the lack of standardized metadata creates “a waste of money” and “unnecessary administrative burden” for rights holders [2].
- *Reputational Damage:* Failure to address metadata issues can also lead to reputational damage for publishers and labels, particularly in relation to artist relations and public perception of the music industry. Eriksson observes in [8] that inaccurate metadata and “rotten data” can undermine trust and confidence in the music ecosystem, potentially harming the industry’s overall reputation.

In essence, music metadata challenges directly impact the financial performance and operational efficiency of publishers

and labels, creating unnecessary costs, hindering revenue generation, and potentially damaging their reputation within the industry and the wider creative community.

#### C. Collective Management Organizations (CMOs)

CMOs, as intermediaries responsible for collecting and distributing royalties on behalf of rights holders, are particularly affected by music metadata challenges.

- *Data Processing Burden:* CMOs face a significant data processing burden in handling vast amounts of usage data from diverse sources, often with inconsistent formats and incomplete information. According to Arenal in [15], CMOs often handle metadata that is problematic, lacking accuracy, completeness, and consistency, and synchronization internationally across the music industry.
- *Matching and Reconciliation Difficulties:* CMOs struggle to accurately match usage data with corresponding musical works and rights holders due to metadata inconsistencies and incompleteness. As Hadziarapovic et al. note in [13], “the black box within the copyright world” refers in part to the difficulties CMOs face in “knowing who to give the collected money to” due to metadata limitations.
- *Increased Administrative Costs:* The manual processes required to correct metadata errors, reconcile conflicting data, and track down rights holders contribute to increased administrative costs for CMOs. These costs are part of the broader industry-wide financial impact of metadata issues discussed earlier, a significant portion of which falls on CMOs [11].
- *Transparency and Accountability Concerns:* The lack of transparency in CMO operations and royalty distribution processes, compounded by metadata challenges, has led to concerns about accountability and fairness among rights holders. As Hadziarapovic et al. highlight in [13], issues like outdated IT systems and a lack of data standardization contribute to these concerns. Lefever adds in [5] that the unwillingness of stakeholders to share collected data without incentive impairs the transparency of licensing processes.

In short, music metadata challenges directly impact the operational efficiency, administrative costs, and transparency of CMOs, hindering their ability to effectively fulfill their role as intermediaries in the music rights ecosystem and potentially undermining trust and confidence among their members.

#### D. Digital Service Providers (DSPs)

DSPs, as the primary platforms for music consumption in the digital age, also face significant challenges related to music metadata management.

- *Data Acquisition and Integration Costs:* DSPs incur significant costs in acquiring, cleaning, and integrating metadata from various sources, often with inconsistent formats and varying levels of quality. As Lyons et al. note in [2], the lack of cooperation between data providers and the increasing fragmentation of datasets contribute to rising administrative costs for data management.

- *User Experience Limitations:* Incomplete or inaccurate metadata can negatively impact the user experience on DSPs, hindering music discovery, search, and recommendation features. As Brooke discusses in [3, p. 33], financial benefits are crucial in business decisions, and improved user experience through richer metadata can provide a competitive advantage and increase sales, as shown by studies indicating that richer metadata in library catalogs leads to greater circulation and better search results.
- *Licensing and Legal Risks:* DSPs rely on accurate metadata to ensure proper licensing and avoid copyright infringement. Metadata inconsistencies and incompleteness can create legal risks and expose DSPs to potential lawsuits from rights holders. Elton points out in [9] that the absence of a central entity with a comprehensive authoritative database of musical works information has led to significant legal costs for DSPs, as seen in the legal settlements between Spotify and music publishers in the United States.
- *Competitive Disadvantage:* DSPs that fail to address metadata challenges and provide a seamless and user-friendly music experience may face a competitive disadvantage in the increasingly crowded streaming market. For this Lefever states in [5] that “poor quality of metadata also results in missed licensing, innovation and business opportunities”, while Brooke adds in [3, p. 33] that richer metadata would lead to improved user experience, which in turn would yield increased revenues.

In essence, music metadata challenges directly impact the operational costs, user experience, legal risks, and competitive position of DSPs, hindering their ability to thrive in the digital music ecosystem and potentially undermining their long-term sustainability.

## V. PROPOSED AND IMPLEMENTED SOLUTIONS

#### A. Standardization Efforts

Standardization has emerged as a key proposed solution to address the music metadata challenges. Building on the crucial role of metadata standards discussed earlier, several standardization efforts have been undertaken in the music industry and related fields, each with its own scope and approach:

- *DDEX (Digital Data Exchange):* DDEX stands out as a significant industry-led initiative aimed at establishing standardized messaging protocols and data formats for the digital music supply chain. As Elton explains, DDEX standards provide a common framework for electronic data interchange (EDI), facilitating efficient communication between various stakeholders [9]. However, while DDEX has successfully enabled standardized data exchange between competing industry players, it faces challenges with market dominance, resource duplication, and lacks a framework of incentives to ensure consistent adherence to standards [2, p. 70].

- **MPEG-7 (Multimedia Content Description Interface):** MPEG-7, developed by the Moving Picture Experts Group (MPEG), offers a comprehensive set of tools for multimedia content description, including descriptors of audio and visual features, description schemes for multimedia, and specifications for encoding and transporting metadata. Waters and Allen note that MPEG-7 provides “a comprehensive framework that covers both metadata and annotation”, offering a wide range of tools for describing structural and conceptual aspects of audio-visual content [19]. However, MPEG-7 is a complex and technically demanding standard, and its adoption in the music industry has been limited, particularly in relation to descriptive metadata.
- **Dublin Core Metadata Initiative (DCMI):** DCMI provides a generic set of metadata descriptors that are common across resource types, including music. It includes elements such as title, creator, subject, and publisher, offering a simple and interoperable framework for describing online resources [10]. However, Dublin Core is not specifically tailored to the music domain and lacks the semantic expressivity to capture the nuances of music metadata [20].
- **MusicBrainz Schema:** MusicBrainz, a community-maintained open music encyclopedia, has developed a comprehensive and abstracted metadata schema for musical works, recordings, and artists. Brooke highlights that the MusicBrainz schema is a “fully abstracted model” that provides a robust framework for describing music metadata at various levels of abstraction [3, p. 25]. However, while MusicBrainz offers a valuable model for standardization, its adoption outside the MusicBrainz community remains limited [3, p. 27].

Despite these standardization efforts, a universally accepted metadata schema for the music industry remains elusive. Achieving industry-wide consensus on metadata standards is a complex political and economic challenge, hindered by conflicting interests, legacy systems, and a lack of clear incentives for collaboration.

#### B. Unique Identifiers

Unique and persistent identifiers (PIDs) emerge as another crucial component of proposed solutions to the music metadata morass. As Elton emphasizes, standardized identifiers are essential for “identifying music-related parties, intellectual property, publications, products, and releases”, providing a common reference point for data exchange and interoperability [9].

Several unique identifiers are currently used in the music industry, each with its own scope and purpose:

- **ISRC (International Standard Recording Code):** ISRC is the most widely used identifier for sound recordings, providing a unique and persistent identifier for each distinct recording. Lefever explains that ISRC is “used ubiquitously to identify recordings” and is crucial for tracking and managing sound recording rights [5]. However, ISRC is limited to sound recordings and does not directly link to the underlying musical work or composition [3, p. 41].
- **ISWC (International Standard Musical Work Code):** ISWC is designed to identify musical works (compositions), providing a unique and persistent identifier for each distinct musical creation. According to Elton, ISWC is used when activity or information related to musical works needs to be tracked or managed, particularly in relation to public performance and mechanical royalties [9]. ISWC adoption is less widespread than ISRC, and the linking between ISWC and ISRC remains a significant challenge.
- **IPI (Interested Party Information):** The IPI system is specifically designed for identifying parties with interests in musical compositions, such as composers and music publishers. According to Elton [9], the IPI system is widely used by performing rights societies around the world to ensure that royalties are properly routed to the appropriate rights holders. More than 4.5 million IPI codes have been assigned to date, making it a comprehensive system for party identification in the music publishing sector. The IPI system forms part of CISAC’s Common Information System (CIS), which is managed by the International Confederation of Societies of Authors and Composers (CISAC), a global network of authors’ societies that aims to protect the rights and promote the interests of creators worldwide.
- **IPN (International Performer Number):** Complementing the IPI system for authors and publishers, the IPN was developed specifically for performing artists. According to Elton [9], the IPN is widely used by performers’ rights societies worldwide to ensure that royalties are routed to the appropriate parties. The system was established in 1994 by the Societies’ Council for the Collective Management of Performers’ Rights (SCAPR) to build a single global database of performers and associate performer data with recordings. SCAPR’s Virtual Recording Database (VRDB) uses the IPN to facilitate the international exchange of performer information, enhancing the efficiency of royalty distribution to performers. The system is widely used with over 700,000 IPNs having been assigned to date [9].
- **ISNI (International Standard Name Identifier):** ISNI serves as a generic tool for identifying contributors to all creative works, including musicians, writers, and publishers. Unlike IPI and IPN, which are specific to the music industry, ISNI has a broader scope and can identify contributors across various creative sectors. Elton [9] notes that the adoption of ISNI in the music industry is growing, with several music-related entities now authorized to serve as registration agencies. One of the principal benefits of ISNI compared to IPI or IPN is that it can connect different contexts, such as linking a songwriter’s social media page to recordings of their compositions or productions.
- **GRid (Global Release Identifier):** GRid is intended to

identify digital releases, providing a unique and persistent identifier for each distinct digital product. Brooke explains that GRid was developed by RIAA and IFPI to identify digital releases as abstract entities containing bundles of digital resources, though it primarily addresses just one level of abstraction and lacks a rich descriptive metadata database [3, p. 42].

- **MBID (MusicBrainz Identifier):** MBID, developed by MusicBrainz, is a unique and persistent identifier for various music entities, including artists, recordings, releases, and works. Brooke highlights that MBID offers an identifier system that provides a robust framework for linking metadata across different levels of abstraction [3, p. 41]. However, MBID faces adoption challenges outside the MusicBrainz community, with its database of 16.1 million tracks being significantly smaller than other industry databases.

The coexistence of these different identifiers, each with its own scope and limitations, further contributes to the music metadata problem. The need for a “Globally Unique Abstracted Persistent Identifier” (GUAPI), as proposed by Brooke, remains a pressing issue for the music industry to consider.

### C. Emerging Technologies and Initiatives

Emerging technologies and industry initiatives offer potential pathways towards addressing the metadata management challenges. Blockchain technology, artificial intelligence (AI), and machine learning (ML) have all been proposed as potential solutions, each with its own strengths and limitations.

- **Blockchain Technology:** Blockchain, a decentralized and distributed ledger technology, has been promoted as a potential game-changer for music metadata management. Torbensen and Ciriello explore how blockchain technology makes it possible to “track and collect royalty income and payout, potentially increasing the scalability of the licensing process through smart contracts, automated and intermediary-free royalty payouts, and micropayments via cryptocurrency, as well as the possibility to detect metadata discrepancies” [14]. Hardjono et al. further propose an “open and scalable music metadata layer” based on blockchain, envisioning a decentralized and interoperable infrastructure for music metadata exchange [12]. However, blockchain adoption in the music industry remains in its early stages, and challenges related to scalability, governance, and industry acceptance need to be addressed [14].
- **AI and Machine Learning:** AI and machine learning technologies offer promising tools for automating and enhancing metadata creation and management. As Deliege and Pedersen explore, AI and ML can be used for “automated classification of song descriptors”, enabling content-based music analysis and retrieval [21]. Arenal et al. note that AI is now “fully present in the industry from the way music is created and produced to how it is consumed and experienced”, though they also point out

that AI technologies have “significantly added complexity to tracing creative processes” [15]. Moreover, challenges related to data quality, bias, and the “semantic gap” between low-level features and high-level musical concepts need to be overcome for AI and ML to fully realize their potential in music metadata management [22].

- **Industry Initiatives:** Alongside technological solutions, various industry initiatives are also emerging to address the music metadata morass. DDEX, as discussed earlier, plays a crucial role in promoting standardization and data exchange protocols, having achieved substantial success in gaining increasing adoption and membership worldwide. However, while DDEX relies on self-regulating principles, it faces ongoing challenges with market dominance among members, lacks a framework of meaningful incentives to ensure adherence to standards, and struggles to include smaller industry players like DIY artists and independent labels [2, p. 70].

### D. Case Studies

Several case studies provide valuable insights into the challenges and potential solutions for music metadata management.

- **The Failure of the Global Repertoire Database (GRD):** The GRD project, as discussed by Torbensen and Ciriello, serves as a cautionary example of the challenges of achieving industry-wide consensus and collaboration on metadata standardization [14]. The GRD’s failure, despite its ambitious goals and broad industry support, highlights the political, economic, and technical complexities of creating a centralized and authoritative music metadata database. Torbensen and Lyons report that the GRD project failed due to a lack of agreement on data standardization and withdrawal of support from collecting societies, underscoring the need for a more collaborative and inclusive approach to metadata governance [2], [14].
- **MusicBrainz as a Community-Driven Solution:** MusicBrainz, as analyzed by Brooke, offers a contrasting example of a successful community-driven approach to metadata management [3]. MusicBrainz’s open-source, collaborative model, its comprehensive and abstracted metadata schema, and its focus on data quality and accuracy demonstrate the potential of community-based initiatives to address the complexities of music metadata management. Swartz explains that MusicBrainz’s “semantic web service” approach and its reliance on RDF technologies enable data linking and interoperability, offering a model for future metadata systems [23].
- **The Echo Nest (now Spotify):** The Echo Nest, as examined by Eriksson, exemplifies the growing importance of AI and machine learning in music metadata management [8]. The Echo Nest’s acquisition by Spotify further underscores the strategic value of metadata in the streaming age and the potential for AI-powered metadata solutions to enhance music discovery and recommendation. However, Eriksson’s analysis also highlights the challenges of

“rotten data” and the need for critical reflection on the limitations and biases of algorithmic metadata generation. These case studies provide valuable lessons for future metadata management efforts, highlighting the importance of collaboration, standardization, community engagement, and the strategic use of emerging technologies.

## VI. DISCUSSION: ADDRESSING THE MUSIC METADATA CHALLENGES

### A. Synthesizing the Challenges

The literature review reveals a complex and multifaceted set of metadata management challenges, characterized by a confluence of technical, economic, political, and social factors.

- *Data Inconsistency and Incompleteness:* The widespread lack of accurate, complete, and consistent metadata across various databases and platforms remains a fundamental obstacle to efficient music information management.
- *Data Silos and Lack of Interoperability:* The fragmented and siloed nature of music metadata repositories, coupled with the absence of standardized exchange protocols, hinders data sharing and integration, creating operational inefficiencies and limiting the potential for innovation.
- *Complex Rights Management and Licensing:* The intricate web of music rights ownership and licensing schemes, compounded by territorial variations and a lack of transparency, further complicates metadata management and royalty distribution.
- *Legacy Systems and Technological Limitations:* The music industry’s reliance on outdated systems and manual processes, coupled with the limitations of existing technologies, hinders scalability, efficiency, and adaptability in metadata management.
- *Lack of Standardized Schemas and Vocabularies:* The absence of a universally accepted metadata schema and standardized vocabularies creates inconsistencies in data structure and content, impeding interoperability and semantic understanding.
- *Governance and Collaboration Deficits:* Conflicting interests, power imbalances, and a lack of trust among stakeholders hinder industry-wide collaboration and governance efforts to address the music metadata challenges.
- *Economic and Political Barriers:* Economic disincentives, political complexities, and a lack of clear value proposition for stakeholders impede the adoption of new metadata solutions and standardization efforts.

### B. The Role of Collaboration and Governance

Addressing the music metadata challenges requires a coordinated and collaborative effort from all stakeholders in the music industry. As Lefever argues, “any effort in this direction [of reaching full potential of the digital creation and digital distribution of creative works] will require collaboration between all actors involved in the value-chains of creative products and services to gain sufficient traction and make a real impact” [5].

Collaboration should focus on:

- *Data Standardization:* Establishing and adopting industry-wide metadata schemas, vocabularies, and exchange protocols to ensure interoperability and data consistency.
- *Data Sharing and Exchange:* Developing mechanisms for secure and efficient data sharing and exchange between different organizations and platforms, overcoming data silos and fragmentation.
- *Best Practices and Guidelines:* Developing and promoting best practices and guidelines for metadata creation, management, and usage to improve data quality and accuracy.

Effective governance is essential for addressing the political and economic obstacles to collaboration and standardization. According to Lyons et al., the absence of governance in data exchange can lead to significant inefficiencies, and a networked system of data governance is necessary to tackle these issues [2, p. 73]. Governance models should consider:

- *Inclusivity and Representation:* Ensuring that all stakeholders, including artists, songwriters, labels, publishers, CMOs, DSPs, and technology providers, are represented in the governance process and have a voice in decision-making. As Lefever points out, a “majority of stakeholders” is needed to support any effective solution, and “the support of the artistic community” is particularly crucial [5].
- *Transparency and Accountability:* Establishing transparent and accountable governance structures to build trust and confidence among stakeholders. Lefever emphasizes that “transparency and better data management is another push towards efficient solutions”, and “creating an efficient metadata infrastructure is an issue of governance and coordination” [5].
- *Incentives and Sanctions:* Developing appropriate incentives to encourage participation and collaboration, as well as mechanisms for addressing non-compliance and enforcing data quality standards. Elton highlights that without sufficient incentives, parties are generally not willing to change their standards implementation behavior, emphasizing the need for clear incentives and accountability mechanisms [9].

### C. Emerging Technologies and Solutions

Emerging technologies, particularly blockchain and AI/ML, offer promising tools for addressing specific aspects of the music metadata challenges.

- *Blockchain for Transparency and Trust:* Blockchain’s decentralized and transparent nature can enhance trust and accountability in music metadata management, particularly in relation to rights management and royalty distribution. As Hardjono et al. propose, blockchain can provide “a single global database of performers, and associate performer data with sound recordings and audiovisual works”, creating a more transparent and equitable system for rights holders [12]. However, challenges

related to scalability, data privacy, and industry adoption need to be addressed for blockchain to fully realize its potential.

- **AI and Machine Learning for Data Quality and Efficiency:** AI and ML technologies can be leveraged to automate metadata creation, enhance data quality, and improve the efficiency of data management processes. As Deliege and Pedersen explore, AI and ML can be used for “automated classification of song descriptors”, reducing manual effort and improving data accuracy [21]. However, ethical considerations, data bias, and the “semantic gap” between machine-generated features and human understanding need to be carefully considered in the application of AI and ML to music metadata.

#### D. Data Quality Considerations

The concept of “rotten data”, as explored by Eriksson, highlights the inherent limitations and biases of large-scale, algorithmically-driven metadata systems [8]. Eriksson’s analysis of The Echo Nest’s metadata archive reveals the presence of “odd, surprising, and peculiar data”, stemming from data inconsistencies, algorithmic biases, and the limitations of automated data collection processes.

The implications of “rotten data” are significant:

- **Undermining Data Quality and Reliability:** “Rotten data” undermines the overall quality and reliability of music metadata, creating inaccuracies and inconsistencies that can hinder data integration, interoperability, and efficient usage.
- **Reinforcing Algorithmic Bias:** Algorithmic systems trained on “rotten data” may perpetuate and amplify existing biases, leading to skewed or unfair outcomes in music discovery, recommendation, and royalty distribution.
- **Challenging Notions of Objectivity and Truth:** The presence of “rotten data” challenges the notion of metadata as objective and neutral representations of musical works, highlighting the inherent subjectivity and interpretation involved in data creation and management.

Addressing the challenges of “rotten data” requires a critical and reflexive approach to metadata management, acknowledging the limitations of automated systems and emphasizing the importance of human oversight, data curation, and continuous quality improvement.

#### E. Future Directions

Addressing the music metadata problem requires a multifaceted and holistic approach, combining standardization efforts, technological innovation, collaborative governance, and a renewed focus on data quality and accuracy. Key recommendations for moving forward include:

- **Prioritizing Standardization:** The music industry should prioritize the development and adoption of industry-wide metadata schemas, vocabularies, and exchange protocols, building upon existing initiatives such as DDEX and MusicBrainz.

- **Investing in Data Quality and Curation:** Stakeholders should invest in data quality improvement initiatives, including data cleaning, validation, and enrichment processes, and promote best practices for metadata creation and management.
- **Embracing Emerging Technologies:** The music industry should explore the potential of blockchain and AI/ML technologies to enhance metadata management, while carefully considering their limitations and ethical implications.
- **Fostering Collaboration and Governance:** Industry-wide collaboration and governance frameworks are essential for overcoming political and economic barriers to metadata standardization and interoperability. A multi-stakeholder approach, involving artists, songwriters, labels, publishers, CMOs, DSPs, and technology providers, is crucial for building trust, ensuring accountability, and promoting equitable outcomes.
- **Promoting Education and Awareness:** Education and training programs are needed to improve data literacy and awareness among all stakeholders, particularly artists and songwriters, empowering them to effectively manage their metadata and advocate for their rights.

## VII. CONCLUSION

This literature review has explored the multifaceted challenges of music metadata management, highlighting the complex ecosystem that impacts efficiency, transparency, and equity in the digital music environment. While the challenges are significant, the review also reveals promising pathways forward, emphasizing the potential of standardization, technological innovation, collaborative governance, and a renewed focus on data quality and accuracy.

Addressing music metadata management is not merely a technical or economic challenge; it is a cultural and ethical imperative for the music industry. Music metadata, as “data about data”, shapes how we understand, experience, and value music in the digital age. By working together to create a more efficient, transparent, and equitable music metadata ecosystem, the music industry can unlock the full potential of digital music information, empowering creators, enriching user experiences, and fostering a more sustainable and vibrant future for music.

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