A Systematic Overview of the Inconsistencies in Metadata in Digitally Stored Music and Methods to Address Them

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ABSTRACT

Music metadata plays a fundamental role in organizing, retrieving, and managing digital music collections. However, inconsistencies in metadata—such as a lack of standardized schemas, human errors, incomplete records, and fragmentation across multiple databases—create challenges in ensuring interoperability and reliability across platforms. This literature study systematically reviews research on metadata inconsistencies in the music domain, focusing on the key challenges and the methods proposed to address them. The study explores approaches such as metadata standardization efforts, database linking techniques, ontology-based models, and distributed metadata storage solutions.

KEYWORDS

Systematic Literature Review, Music, Music Metadata Inconsistencies

1 INTRODUCTION

Music has been deeply embedded in human civilization since prehistoric times, evolving alongside technological and cultural advancements to become a ubiquitous element of modern life. Today, music is omnipresent in various environments such as bars, supermarkets, and public spaces, shaping both individual experiences and commercial strategies. Beyond its psychological benefits, such as mood enhancement and therapeutic effects [16], music also plays a crucial role in business, influencing consumer behavior and directly impacting revenue generation, regardless of business size [12].

With the rapid advancement of digital technology, a vast amount of data is being generated, stored, and exchanged every day. To efficiently manage and organize this data, systems rely on metadata—structured information that describes, categorizes, and facilitates the discovery of digital assets. Metadata plays a crucial role across various domains, enabling effective search, retrieval, and organization of information in an increasingly digital world. The presence of metadata assists in multiple use cases in different research areas, for example, data identification, classification, retrieval, and data set validation.[20].

In the realm of digital music storage, metadata serves a similar function, enabling the organization, retrieval, and identification of music files. As described in [19], the most common metadata that is stored to describe the music file are its audio properties (such as song length), meta tags, and a digital "fingerprint", a unique identifier derived from an audio file's characteristics, remains consistent across different formats and compression methods, ensuring reliable music identification. In the context of digitally stored music, metadata is of paramount importance, especially due to the economic value it holds. With incorrect or improper mapping, we are one step further behind in correctly identifying the personnel involved in the creation of the music piece and ensuring compensation to them.

This study explores the challenges associated with metadata inconsistencies, including discrepancies in metadata formats, missing or incorrect information, and interoperability issues across different platforms. Additionally, it examines existing solutions such as metadata standardization efforts, open APIs like MusicBrainz, and distributed approaches to metadata management. By mapping the current state of the art, this study aims to identify gaps in existing research and highlight potential improvements for more efficient and scalable metadata integration within digital music ecosystems.

2 RELATED WORK

Over the years, multiple studies have examined the challenges of managing metadata in digital music, focusing on issues such as schema standardization, metadata inconsistencies, and the impact of fragmented metadata systems.

Sherry Vellucci [21] provides a detailed insight about how the organization and arrangement of metadata had been carried out by the music community the turn of the century. She explains how at that time, the main focus was to evaluate how effective the Dublin Core Metadata Element Set [22] was, which was the state-of-the art at that time, rather than developing a metadata scheme just for music.

Arjan Scherpenisse's thesis [19] investigates the challenges of music identification due to imprecise metadata. According to the thesis, this imprecision arises from factors such as spelling errors, incomplete data, and compression artifacts affecting metadata integrity. Furthermore, Scherpenisse provides evidence that metadata quality correlates with artist popularity, with well-known artists having more reliable metadata compared to lesser-known ones. The thesis then explores how MusicBrainz, a community-driven music metadata database [5], addresses these issues through a combination of human moderation and automated data-cleaning techniques. Finally, the author discusses how MusicBrainz ensures metadata accuracy and suggests multiple approaches to further improve metadata management within the platform.

'Discovering Metadata Inconsistencies' by Angeles et al. [6] performs a comparison between the quality of manually maintained metadata in a database called Codaich [17] against an unprocessed test collection, consisting of music files obtained from file sharing services using the jMusicMetaManager software [17], which can automatically detect inconsistencies in metadata. In this study, MusicBrainz was used as the benchmark to detect these inconsistencies. The results indicated that the manually curated Codaich database had significantly higher metadata consistency compared to the unprocessed test collection, which contained numerous inaccuracies, missing data, and variations in metadata entries. This highlights the importance of structured metadata curation and suggests that relying solely on community-driven metadata sources like MusicBrainz may not always guarantee accuracy.

Tony Brooke's 2014 paper about descriptive metadata [9] provides insights about why descriptive metadata is 'broken,' and these insights are extremely similar to those discovered in [21], [19], and [6] (such as the absence of a standardized schema for metadata, spelling mistakes, etc.). The differentiating factor, however, is that Brooke describes these issues as they exist in real-world industry settings. For example, the study highlights how a track purchased from an online store will often lack metadata that identifies co-producers or session musicians involved in the track's creation. Moreover, the research explains that with the rise of digital music distribution, multiple metadata vendors developed distinct schemas, leading to further fragmentation. This inconsistency required either schema translators or manual metadata entry, which introduced additional errors and inefficiencies. As a result, these inconsistencies have direct financial ramifications on the music industry, particularly in royalty payments and proper attribution.

To complement Brooke's research with a more recent study, the research by Barone et al. [7] highlights similar problems with music metadata that are due to multiple metadata vendors. The study highlights that platforms such as MusicBrainz, Discogs, and streaming services use separate metadata identifiers, making it difficult to unify music information. This lack of a centralized identity resolution system results in metadata inconsistencies, duplicate entries, and difficulties in linking artists, albums, and tracks across databases.

3 STUDY DESIGN

The guide on how to conduct a systematic literature review by Rivera et al. [10] has been referred to in order to successfully design and conduct this systematic literature review.

3.1 Research Goal

The research was designed with the goal analyzing inconsistencies that exist in metadata when it comes to digitally stored music, and to study the techniques that have been employed to address them. More specifically, by following the Goal-Question-Metric approach [8], the goals of this literature study can be formalized as follows:

Purpose	Identify and analyze metadata inconsistencies in digitally stored music and examine existing approaches to solve them.
Issue	Lack of structured metadata, inconsistencies across metadata formats, and interoperability issues between different metadata systems.
Object	Metadata records stored across multiple music metadata systems (e.g., MusicBrainz, streaming platforms, proprietary databases).
Viewpoint	From the perspective of metadata accuracy, interoperability, and standardization in digital music ecosystems.

Table 1: GQM Definition

3.2 Research Questions

In order to define a research question, I have first defined the PICOC criteria [10].

Population	Studies analyzing metadata inconsistencies in digital music and methods used to address them.
Intervention	Identification and evaluation of metadata inconsistencies in various metadata schemas, as well as techniques applied to address them.
Comparison	Different types of metadata inconsistencies and approaches to handling metadata inconsistencies (e.g., manually curated vs. community-driven metadata, ontologies, etc).
Outcome	Understanding metadata issues and their impact on metadata accuracy, standardization, and interoperability, as well as assessing the techniques applied to overcome them.
Context	Digital music metadata across academic research databases, community-driven platforms, and industry standards.

Table 2: PICOC Criteria Definition

From the PICOC criteria formulated above, I have proposed **two** research questions for this literature study, which are mentioned below:

> **RQ1:** How has the problem of inconsistency in metadata representing digitally stored music persisted and evolved over time?
> **RQ2:** Which techniques have been applied to address inconsistencies in metadata representing digitally stored music?

3.3 Initial search

A structured query was generated based on the PICOC criteria defined above and was executed on ResearchGate [1] and Google. This search retrieved the relevant literature used in this study. The following query was used:

> ((music metadata) AND (music metadata inconsistencies OR digital music metadata challenges OR music metadata fragmentation) AND (music metadata schema OR MusicBrainz OR music metadata interoperability))

Running this query generated a very large number of results. The first step in the filtering process was to look at the title and abstract for each of the results (until a sufficient number of studies were found), and the results were then filtered out based on how well they fit the selection criteria (described below).

3.4 Application of selection criteria

Once the studies were obtained from the initial search query, the following inclusion and exclusion criteria were applied in order to filter out the studies that are relevant within the scope of this literature review. The inclusion-exclusion criteria are described below:

- I1- Studies that focus on metadata inconsistencies in digitally stored music. This inclusion criterion is utilized to select exclusively studies discussing metadata.
- I2- Studies that analyze the effects of metadata inconsistencies. Papers must examine how metadata inconsistencies impact data accuracy, interoperability, retrieval, and broader consequences on artists as well as the music industry.
- I3- Studies discussing potential solutions (both theoretical and practical) to address metadata inconsistencies. This criterion ensures the inclusion of what has been tried and what could be tried.
- I4- Studies that are publically available, or can be accessed through institutional credentials. This criterion ensures access to peer-reviewed and relevant research searches.
- E1- Studies that focus on metadata inconsistencies in general but do not focus specifically on metadata for digitally stored music.
- E2- Opinion pieces, blog posts, and non-peer-reviewed sources. Only peer-reviewed journal articles, conference papers, academic theses, and reputable industry reports will be included.
- E3- Duplicate papers or extensions of already included papers, in order to avoid possible threats to conclusion validity.
- E4- Papers that are not publically available and papers that cannot be accessed through institutional credentials.

3.5 Snowballing

A backward snowballing approach was applied by reviewing the reference lists of the studies that have been documented in the 'Data Synthesis' section. However, this process did not yield additional relevant literature, as the most relevant papers had already been retrieved through the structured search query. As a result, no further studies were included from backward snowballing.

3.6 Quality Assessment Checklist

A Quality-Assessment checklist was created, and each study included in this literature review was assigned a score based on the how well they fulfilled each item in the checklist. The following scoring methodology was used:

Description	Weight
Yes	1.0
Partially	0.5
No	0.0

Table 3: QA Scoring

The process of making the QA checklist as well as scoring each study was done on **Parsif.al** [2].

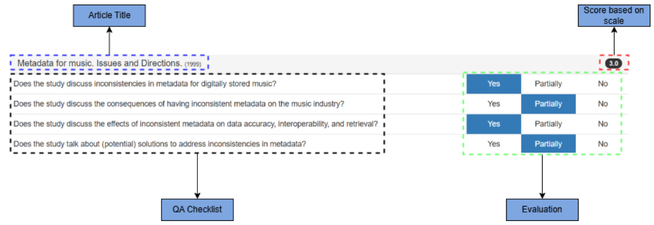

Figure 1: Quality Assessment Checklist

3.7 Data Extraction

A data extraction form was generated on Parsif.al, and the articles that passed the study selection phase were read thoroughly. The data extraction form for the study by Angeles et al. [6] has been showed below in Figure 2.

Figure 2: Data Extraction Form

The papers that have been reviewed in this literature study are given in the table below:

Ref	Title
[11]	The Music Meta Ontology: A Flexible Semantic Model for the Interoperability of Music Metadata
[18]	MusicPedia: Retrieving and Merging-Interlinking Music Metadata
[13]	Towards an Open and Scalable Music Metadata Layer
[14]	Making Metadata: The Case of MusicBrainz
[9]	Descriptive metadata in the music industry: Why it is broken and how to fix it, part 1
[6]	Discovering Metadata Inconsistencies
[7]	GRAIL: Database Linking Music Metadata Across Artist, Release, and Track
[21]	Metadata for music. issues and directions
[19]	Giving music more brains: A study in music metadata management

Table 4: Extracted Literature

3.8 Data Synthesis

The extracted data was synthesized by categorizing metadata inconsistencies, identifying common patterns in errors, and evaluating the proposed solutions and grouping them by the type of solution that is proposed. Studies were grouped based on their focus areas, such as types of inconsistencies, applied techniques, and validation methods.

3.9 Study Replicability

The replicability of this study primarily depends on the reviewer who is performing the literature review. Running the search query that is mentioned above on ResearchGate will give the same papers (and any new research in the future). But it is highly dependent on the reviewer's interpretation of the papers they choose, even if they choose the same set of papers that have been reviewed in this literature study. Due to the large number of results that were obtained when the search query was run, however, it is not as likely that the same set of papers will be chosen. My selection of the literature included in this review is highly dependent also on the inclusion/exclusion criteria, and my research questions for the study.

3.10 Threats to Validity

One threat to the validity is that the research used in this review is dependent on external APIs (such as Grail, MusicBrainz), which are considered to be state-of-the-art. However, if the APIs are discontinued, we risk losing these benchmarked metadata databases at least until a new benchmark is created. Secondly, only a limited number of studies have been analyzed as part of this review. If more papers were analyzed, especially discussing the proposed or applied solutions to address metadata inconsistencies, it would have further strengthened this review.

4 RESULTS

The results of this literature study are explain in detail in the subsections below. The results are divided into subsections, where the first section explains the problems that exist in metadata creation and management for digitally stored music, and the second section explains methods to address them.

4.1 Inconsistencies in Metadata

The analysis of the literature that is reviewed consistently reveals various forms of inconsistencies in metadata that surround digitally stored music. This section details the key categories of metadata inconsistencies that emerged from the systematic review, and provides an answer for the research question **RQ1**, as formulated in section 3.2.

4.1.1 ***Lack of Standardized Metadata Schemas:*** One of the foundational issues, repeatedly emphasized throughout the literature, is the lack of standardized metadata schemas within the digital music ecosystem. As Vellucci [21] pointed out in her historical overview, even at the turn of the century, the focus was on adapting general metadata schemes like Dublin Core rather than developing music-specific standards. This absence of a universally adopted schema has paved the way for a fragmented environment where there are varying interpretations and implementations of metadata fields. Also, Vellucci highlights how due to the lack of a standardized schema, it became extremely complex to describe very complex digital objects, which digital music normally is, due to the descriptive information that they are made of.
Brooke [9] further underscores this point by highlighting how, with the rise of digital music distribution, multiple metadata vendors developed distinct schemas. This divergence inherently leads to inconsistencies as the same piece of musical work can be described differently depending on the source. This lack of standardization manifests in several practical problems, including format discrepancies and variations in metadata fields. For example, even seemingly basic fields like "artist name" or "track title" can be represented with variations in capitalization, punctuation, or the inclusion of extraneous information. Furthermore, the granularity and scope of metadata can differ significantly. Some schemas might prioritize detailed information about session musicians and co-producers, while others might focus solely on the primary artist and album [9]. This variability makes it challenging to aggregate and compare metadata from different sources reliably.

4.1.2 ***Inconsistencies Due to Human Errors:*** Beyond structural inconsistencies, the literature also points to issues related to the content quality of metadata itself. A recurring problem is the presence of spelling errors and typographical mistakes. Scherpenisse's thesis [19] explicitly identifies **spelling errors** as a contributing factor to metadata imprecision, impacting music identification accuracy. These errors, while seemingly minor, can significantly impede search and retrieval processes, especially when relying on text-based queries.
Hemerly further builds upon and describes this problem in her master thesis from 2010 [14]. She explains the 'Guns N' Roses Issue' that was written about by an employee in the company blog for Last.fm [4]. Hemerly explains that in the blog, the writer provides

evidence regarding the different ways users represented the song 'Knockin' on Heaven's Door' by Guns N' Roses. There were apparently more than 100 ways that the users had represented the track in their music metadata, ranging from the correct text (Guns N' Roses - Knockin' On Heaven's Door) to text such as Guns And Roses - Knocking On Heaven's Door. This claim also provides evidence about the fact that a lack of standardization is a cause of inconsistencies due to human errors.

4.1.3 ***Incomplete and Ambiguous Metadata:*** Another critical category of inconsistency arises from incomplete or missing metadata. Vellucci's paper [21] classifies four states of a resource – *work*, which refers to the abstract intellectual or artistic creation, *expression*, that represents its realization (e.g., a performance or score), *manifestation*, the physical or digital embodiment (e.g., a specific edition), and *item*, a single, tangible copy (e.g., a particular CD or score). The paper explains that there was ambiguity in descriptions of artifacts, such as the date. In the context of Vellucci's research, she explains how "date" could mean several things, such as the recording date of the music piece, the date of performance of the music piece, and so on.

To expand more on the ambiguity that comes with different meanings of attributes of the metadata for a song, there is the challenge of inconsistent handling of multiple 'versions' of a single musical work, as explained in the paper by Hardjono et al. [13]. Their paper highlights that different releases of the same song—such as original recordings, remixes, live performances, and radio edits—are often treated as separate metadata entries across different databases rather than being systematically linked. This results in inconsistencies in metadata retrieval, misidentification issues, and difficulties in aggregating complete metadata records. The fragmentation is particularly problematic in licensing and rights management, where different versions of a song may have distinct rights holders, yet metadata systems fail to clearly associate them with the original work. Additionally, these inconsistencies complicate music discovery and searchability, as different platforms may reference the same song under varying metadata structures, making it difficult to track its full discography.

Next, Brooke [9] provides a compelling example of tracks purchased from online stores often lacking metadata for co-producers or session musicians. This omission has direct implications for royalty distribution and proper attribution of creative work. Scherpenisse [19] also highlights incomplete data as a general source of metadata imprecision. The absence of crucial information, whether intentional or accidental, degrades the overall quality and usefulness of the metadata record. Furthermore, ambiguity in metadata fields contributes to inconsistencies. Without clear and consistent definitions for metadata terms, interpretations can vary widely, leading to misinterpretations and inaccurate data. This ambiguity extends beyond dates to other fields where the intended meaning might not be universally understood or consistently applied. Adding to the complexity is the inherent subjectivity in certain metadata labels, such as genre classification, as noted by Brooke. Genre labels are often influenced by cultural context, personal interpretation, and marketing considerations, making them inherently inconsistent and challenging to standardize objectively.

4.1.4 ***Metadata Fragmentation:*** Finally, a significant source of inconsistency stems from the fragmented nature of music metadata identifiers and systems. Barone et al. [7] clearly articulate this problem, demonstrating that major platforms like MusicBrainz, Discogs, and streaming services operate with separate metadata identifiers for artists, albums, and tracks. This lack of a centralized identity resolution system makes it exceedingly difficult to link music information across different databases. The consequence is the creation of duplicate entries, difficulties in tracking artists and their works across platforms, and ultimately, hindered interoperability. Even when platforms contain similar information, the absence of a shared identifier means that systems struggle to recognize them as referring to the same musical entity.

Another significant source of metadata inconsistency in the music industry arises from the lack of a centralized authoritative metadata source. Hardjono et al. [13] that metadata for a single musical work is often stored in multiple locations by different entities (e.g., record labels, streaming services, and rights management organizations), each maintaining their own version, or "repository", of the metadata. This leads to duplication, conflicting records, and difficulties in synchronizing updates across platforms. Unlike industries such as finance, where data accuracy and standardization are tightly enforced through advanced distributed systems, the music industry lacks a widely adopted process for validating, storing, and retrieving authoritative metadata records.

4.2 Methods to Address Inconsistencies

Multiple solutions have been proposed in the research that has been analyzed in this literature review. These solutions fit a plethora of criteria, as described in the sub-subsections below, and they attempt to provide answers that satisfy research question **RQ2**, which is formulated in section 3.2.

4.2.1 ***Standardization of Metadata Schemas:*** One of the most widely discussed solutions is the development and adoption of standardized metadata schemas. Several studies highlight the role of unified metadata frameworks in improving interoperability between different digital music platforms. Vellucci [21] first highlights what the Dublin Core system was already implementing at the time, which were formalization, standardization, additions to existing qualifiers, and implementing the Resource Description Framework [15]. The formalization and standardization processes attempted to approach problems related to specific elements within the metadata, such as a 'date', as well as problems such as modeling the relationship between elements. The research also explains how the Dublin Core was moving to the ISO 11179 formatting standard, which would ensure the formal expression of data elements in a standard fashion. Next, the research explains how Dublin Core permitted the addition of qualifiers to existing elements, which helped in increasing semantic specificity and improving metadata precision. This further allowed for controlled vocabularies, unique identifiers (e.g., DOI, ISBN), and structured sub-elements like creator details. These enhancements improve metadata accuracy and interoperability across systems. Finally, Vellucci discusses the (in progress at the time) integration of Resource Description Framework (RDF) into the Dublin Core system. Metadata in RDF is expressed in XML format, and resources are identified by uniform resource identifiers

(URIs). Furthermore, resources have properties that describe the resource. Metadata properties are linked to their respective schemas, ensuring interoperability across different metadata systems. This enables applications to retrieve structured metadata definitions from public registries, facilitating more advanced relational metadata systems. Vellucci concludes by advocating for the registration of an official RDF schema tailored for music metadata, emphasizing the need for standardization across digital platforms.

Brooke's research [9] complements this argument by noting that using a common set of standards across the whole industry, such as the DDEX suite of standards [3], directly impacts cost saving and an increase in productivity. The DDEX suite of standards is a framework designed to standardize the exchange of digital music metadata, enhances interoperability between record labels, streaming services, and rights organizations. Since the DDEX suite has limitations when it comes to descriptive metadata, Brooke then highlights the develop a framework based on the CCD framework, that generates the metadata during different stages of the production phases of the music piece. But the problem with the CCD framework was that it cannot describe music that is already released as good as it can describe music being made. This motivates the proposition of a 'Globally Unique Abstract Persistent Identifier', or GUAPI.

4.2.2 ***Human Intervention:*** One widely discussed method of improving metadata accuracy is human intervention, particularly through manual moderation and verification. Scherpenisse's thesis [19] highlights how MusicBrainz relies on human moderators to review and validate metadata submissions. Unlike fully automated systems, which can misinterpret metadata due to spelling errors, missing information, or inconsistent formatting, human intervention ensures that metadata entries maintain a higher level of precision. Moderators play a crucial role in correcting discrepancies, resolving ambiguous metadata fields, and preventing duplicate or erroneous entries. While automated retrieval systems can efficiently pull metadata from various sources, the study emphasizes that human oversight remains essential to maintain metadata integrity and to handle cases where automated methods fail.

Scherpenisse's thesis supports the results of the experiment conducted and presented in [6]. The solution proposed in this study is to manually curate a metadata database. The study explains how Codaich, which is a manually curated database of music metadata, had more matches for identical artists, identical albums, and identical titles, for genres such as Classical, Jazz, Popular, and World, as compared to an unprocessed collection of metadata when matched to the MusicBrainz metabase. The study also claims that the Codaich database is even more accurate than the MusicBrainz metadata database for classical music, as it contains a *composer* field, which is supposed to contain the artists' names. Furthermore, Codaich supports multi-value metadata fields, which allow the appearance of metadata in different contexts, such as movie soundtracks or original studio recordings. It also enables separation of concerns, which means that both cases where users want the metadata to be related to the original recording versus a movie soundtrack are supported.

4.2.3 ***Database Linking Across Multiple Music Databases:*** Nikolaidou et al., in their research [18], leverage the principles of the Semantic Web to address metadata inconsistencies through combinatorial and progressive searches. They introduce **MusicPedia**, a web application designed to dynamically integrate music metadata retrieved from separate services such as MusicBrainz, Discogs, and Last.fm into a cohesive, web application for users. Initially, the authors intended to directly merge metadata into a unified schema; however, due to the issue of schema heterogeneity that also persisted at the time the study was conducted, a static merging approach was not possible to do. Instead, the authors adopted a dynamic method where each database is queried sequentially based on user interaction. For example, the initial search might begin with a keyword (e.g., artist name) sent to MusicBrainz, returning matching artists in XML format. Users can then select the artist and they are able to view the discography. This prompts a deeper query to Discogs to retrieve discography details. From there, additional track-level details or artist information can be requested from Last.fm, creating a multi-layered search experience that progressively enriches the available metadata. All of this communication between MusicPedia is done through HTTP requests that are sent to the Application Programming Interface (API) of the services used in this study. This approach effectively leverages the strengths of each individual database while compensating for the limitations and inconsistencies that relate to structural differences across different metadata databases.

The GRAIL (Global Record Linking) API, as proposed by Barone et al. [7], addresses the challenge of fragmentation of information across multiple databases by providing a structured method for linking metadata across different music databases. The system enhances interoperability between platforms such as MusicBrainz, Discogs, and streaming services, enabling more accurate and efficient music data retrieval. GRAIL functions by establishing a linking framework that consolidates metadata entries from various databases, ensuring that different representations of the same musical work are associated correctly. This prevents duplicate metadata entries and enhances consistency in music metadata records. The system employs record-linking algorithms to identify and merge metadata records that refer to the same music entities (e.g., artists, albums, tracks), even when inconsistencies exist in their representation across different databases. A key advantage of GRAIL is its ability to create unique entity identifiers that allow metadata records from disparate sources to be cross-referenced seamlessly. Unlike traditional metadata management systems that rely on separate identifiers per platform, GRAIL integrates these disparate identifiers, allowing for a more comprehensive and interconnected metadata ecosystem. This is particularly useful for music industry professionals, digital platforms, and researchers who require accurate, up-to-date, and consolidated metadata. Furthermore, the API facilitates metadata enrichment by aggregating missing or incomplete information from multiple sources. For instance, an album entry that lacks producer credits in one database may be supplemented with additional metadata from another database. This reduces gaps in metadata records and ensures that music information remains as comprehensive as possible.

4.2.4 ***Ontologies:*** Another study that focuses on building a solution that addresses the challenges related to inconsistent structure across multiple music databases is the Music Meta Ontology, which is introduced in study by Berardinis et al. [11]. The design of the Music Meta Ontology has been implemented so as to fulfill the requirements of all the stakeholders (such as musicologists, librarians, data engineers, etc.) involved. In contrast to the solutions mentioned above, the Music Meta Ontology is not an API or an application, but rather it is a model that describes music metadata consistently. The ontology leverages Semantic Web technologies, particularly RDF (Resource Description Framework) and OWL (Web Ontology Language), to represent music-related entities and their relationships in a structured manner. By defining relationships between metadata elements, the ontology enables automated metadata reconciliation, reducing inconsistencies caused by database-specific representations. A central aspect of metadata inconsistencies is the lack of provenance tracking (keeping a record of where data comes from and how it has changed over time), which results in difficulties in verifying the accuracy and origins of metadata records. The Music Meta Ontology incorporates provenance tracking mechanisms, allowing for source attribution at multiple levels. This is particularly relevant in cultural heritage and archival contexts, where historical records may contain conflicting authorship claims or variations in metadata representation.

4.2.5 ***Distributed Setup:*** A distributed approach to music metadata management is described in the paper by Hardjono et al. [13]. The authors of the paper introduce a new metadata layer, which comprises of two components. The first component is explained as a 'Replicated and decentralized open-access metadata repositories'. This component is a group of open access repositories where *creation metadata* is stored, but no copyrighted material (such as compositional notes or audio files). 'Creation metadata', in the paper, is synonymous to metadata. Also, the authors propose a *distributed search database*. This database serves the purpose of facilitating textual search for metadata from anywhere in the world. It contains attributes such as keywords, phrases, and tags for the metadata. The second component of the proposed architecture is a metadata registry ledger. This ledger is responsible for facilitating the the registration of metadata by the creators of musical works.

They impose certain requirements that the replicated metadata repositories must fulfill. such as easy replication of metadata, maintaining a standard format for cases where the user wants to export a copy of the metadata, and a standard API definition that can make the creation and reading of metadata a smooth process.

The authors also believe that a standalone search infrastructure is a requirement, in addition to the repositories mentioned above.While creation metadata remains largely static once it is signed, search material—consisting of words, tags, and phrases associated with the music—continually evolves. This distinction allows for flexibility in search optimization without altering the core metadata. Additionally, both creators and users should be able to associate their own keywords and tags with music metadata. Artists can attach relevant terms to improve discoverability, while users—including AI systems—can generate their own associations, similar to how personal playlists function in streaming services. This approach ensures that metadata remains stable, while searchability remains dynamic and adaptable over time.

5 DISCUSSION

The findings of this study highlight the persistent challenges in managing metadata for digitally stored music, particularly in terms of standardization, human errors, incomplete data, and fragmentation across multiple databases. The literature provides sufficient evidence that metadata inconsistencies arise due to the lack of a universally adopted schema, variations in metadata entry practices, and discrepancies between different metadata repositories. The studies reviewed indicate that efforts to standardize metadata schemas, such as Dublin Core and DDEX, have provided a partial solution to improving interoperability. However, these approaches remain limited by adoption rates, inflexible data structures, and a failure to accommodate the diverse needs of music metadata users.

A recurring theme in the reviewed studies is the reliance on manual intervention and community-driven moderation to improve metadata accuracy. While platforms such as MusicBrainz use human moderators to verify metadata entries, the approach is time-consuming and inconsistent, as it depends on voluntary contributions. Similarly, manually curated databases, such as Codaich, have demonstrated higher accuracy in metadata consistency, but their limited scalability makes them less effective as an industry-wide solution.

Another method explored is database linking across multiple music databases, which aims to improve metadata retrieval by aggregating information from different platforms. Systems such as GRAIL and MusicPedia introduce record-linking mechanisms that help unify fragmented metadata across services like MusicBrainz and Discogs. However, these solutions are highly dependent on the existence of accurate metadata in the first place, meaning that metadata inconsistencies persist when initial data sources contain errors or missing information.

The use of ontology-based models has also been explored to improve metadata structure and provenance tracking. The Music Meta Ontology presents a flexible semantic model that facilitates the interoperability of metadata across different sources. While this ontology-based approach is useful in defining structured relationships between metadata elements, its effectiveness is dependent on widespread adoption and integration with existing industry systems, which remains a challenge.

A distributed approach to metadata management, such as the open-access metadata registry ledger, has been proposed as a means to address metadata fragmentation and availability issues. By decentralizing metadata storage across multiple repositories and providing a unique metadata registry for verification, this model enhances metadata consistency. However, questions remain regarding governance, sustainability, and the ability to keep metadata records up-to-date in a decentralized system.

Overall, while the reviewed methods address various metadata inconsistencies, no single approach fully resolves all issues. Metadata standardization improves interoperability but lacks flexibility; manual intervention increases accuracy but is not scalable; linking multiple databases enhances metadata retrieval but does not fix existing inconsistencies; ontology-based models improve structure but require adoption; and distributed solutions reduce fragmentation but raise concerns about data governance. These findings indicate that a hybrid approach, incorporating elements of standardization, automation, distributed storage, and manual oversight, may be necessary to effectively manage metadata inconsistencies in digital music ecosystems.

An area that was not explored in depth within this literature review is the application of Artificial Intelligence (AI) as a solution to metadata inconsistencies. Although there is a growing body of research that investigates the use of AI in metadata creation, correction, and management across various domains, no studies were identified that directly addressed AI-based solutions within the specific scope of this review. Future research could benefit from examining how such techniques might be adapted to the music metadata context. As the field evolves, the integration of AI-driven approaches may present a promising avenue for addressing longstanding metadata challenges more efficiently and at scale.

6 CONCLUSION

Music metadata plays a crucial role in ensuring accurate organization, retrieval, and interoperability of music information across digital platforms. However, inconsistencies in metadata have persisted due to a lack of standardization, human errors, incomplete or ambiguous metadata, and fragmentation across multiple databases. These issues impact not only metadata accuracy but also music discovery, rights management, and data integration. Addressing these inconsistencies is essential for improving the reliability of music metadata systems and facilitating better access to music information in a rapidly growing digital landscape.

This study followed a systematic literature review approach, analyzing research on metadata inconsistencies and the methods proposed to mitigate them. The selection process involved identifying studies that examined metadata challenges within the music domain, as well as broader metadata management techniques. By reviewing a range of solutions—including standardization efforts, database linking, ontology-based models, and distributed metadata approaches—this study assessed their effectiveness in addressing inconsistencies and improving metadata quality.

The findings highlight that while standardization initiatives such as Dublin Core and DDEX provide structured frameworks for metadata organization, they are not universally adopted and often lack flexibility. Database linking approaches, such as cross-referencing multiple music metadata sources, improve metadata retrieval but are only as effective as the quality of the initial datasets. Ontology-based models, such as the Music Meta Ontology, offer a more structured and adaptable approach but face challenges in widespread adoption across platforms. Distributed metadata systems, which rely on decentralized storage and registry-ledger models, attempt to solve metadata fragmentation, yet concerns regarding governance, sustainability, and synchronization remain.

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