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RESEARCH PAPER

Blockchain-based digital rights management systems: Design principles for the music industry

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Abstract

Initially designed to protect intellectual property (IP) of digitalized information goods such as music, games, or books, existing centralized digital rights management (DRM) systems mostly serve the interests of major publishers, with scant inclusion of rights owners, creators, and consumers. Although various blockchain-based DRM systems have been proposed, most of them mirror existing counterproductive IP restrictions. Analyzing the music industry as a case in point, this paper proposes design principles for blockchain-based DRM systems that provide an integrated and flexible solution by enabling transparent music licensing structures, consistent and complete rights metadata, and efficient and transparent royalty payout. The solution can be achieved by storing rights metadata on a public distributed ledger, by validating metadata through a consensus mechanism on a permissioned blockchain, and by algorithmically enforcing royalty payout via stablecoin through a smart contract. The design principles were evaluated by industry experts, validating their benefit for the music industry by increasing surplus value that is currently destroyed through previous suboptimal designs.

Keywords Digital rights management · Music industry · Decentralization · Blockchain · Design principles · Scenario-based design · Design science research

JEL Classification L86 · Q55 · O32

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Introduction

Many media industries have been disrupted by digital technologies, such as the Internet, peer-to-peer file sharing networks, and streaming platforms. Media companies reacted by transforming their business models from physical sales to digital downloads and online subscriptions (Burkart, 2008; Riemer & Johnston, 2019). A case in point is the music industry, which loses US$12.5 billion annually to global piracy, according to the Recording Industry Association of America (RIAA, 2022). In response, labels and publishers put significant effort and resources into digital rights management (DRM) systems (Vernik et al., 2011). In the conventional sense, a DRM system provides intellectual property (IP) rights protection and prevents unauthorized use by restricting access and enabling control over usage and distribution of digitalized information goods, such as software, books, videos, games, and music (Foroughi et al., 2002). Most commercial DRM systems use digital watermarks

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to identify IP rights owners and are centrally controlled by major labels and publishers (Kwok et al., 2003). For instance, the original iTunes DRM system restricted copying music on more than five authorized computers. The assumption is that DRM systems benefit rights owners by making piracy costly and difficult (Vernik et al., 2011).

However, DRM systems have been controversial since their inception because they impose restrictions not only on unauthorized consumers, but also on legal consumers, making it difficult to search, discover, access, use, collect, and share digitalized information goods (Burkart, 2008; Foroughi et al., 2002). Existing DRM systems are highly centralized, primarily serving the interests of major labels and publishers, with scant attention to the interests of rights owners and consumers. As a result, notable critics, including Bill Gates and Cory Doctorow, argued that the industry would be better off without such centralized DRM systems (Vernik et al., 2011). Indeed, Zhang's (2018) empirical study shows that in the music industry, removing DRM-enabled access restrictions at the "Big Four" record labels—EMI, Sony, Universal, and Warner—led to a 10% overall increase of record sales, and up to 40% increase for lower-selling niche albums, suggesting that DRM systems can counter-intuitively increase piracy and reduce sales. Nonetheless, DRM systems remain prevalently used in many media industries (ICERights, 2020; Zhang, 2018), because DRM can not only restrict usage, but also enable per-use royalty payout, which could in principle benefit IP rights owners, consumers, and other stakeholders (Kwok et al., 2003). Overall, the current consensus is that DRM systems are necessary, but centralized ones are severely flawed.

In response, music industry observers have proposed that novel DRM systems should be decentralized, based on blockchain (Chong et al., 2019; De León & Gupta, 2017; Marella et al., 2020). However, despite initial enthusiasm (Baym et al., 2019; Heap, 2017), a lacking understanding of the music industry's business problems among blockchain developers, and a lacking understanding of the blockchain technology by music industry experts have hindered effective design and adoption of blockchain-based DRM systems. Due to the complexity of international copyright law and conflicting stakeholder interests, blockchain can only fulfill its promise if it provides an integrated solution to the music industry's business problems (Savelyev, 2018). This provides an opportunity to challenge the assumption that DRM systems must focus on IP protection. Instead, we need to better understand the requirements of various stakeholders in the music industry to then provide prescriptive guidance for developing decentralized DRM systems. This study bridges this gap by addressing the research question: how to design a decentralized DRM system for the music industry?

We approach this research question through a design science research (DSR) study (Hevner et al., 2004; Peffers et al., 2007), and the rest of this paper is structured accordingly. We continue in the following section by summarizing the foundations of DRM systems in the music industry and blockchain-based DRM systems. In the ensuing section, we describe how we applied the DSR methodology. We then establish three design requirements for DRM systems in the music industry, evidenced by extant literature and our empirical data. In the section thereafter, we develop and evaluate three corresponding design principles for decentralized DRM systems. Then, we demonstrate how a decentralized DRM system could be implemented. We conclude by discussing our contributions and by summing up the key insights in the last section of the paper.

Our contribution to the information systems (IS) literature is twofold. First, our design requirements contribute a generalized problem description that may help IS developers better understand the concrete business challenges a DRM needs to solve in the music industry. Second, our design principles for decentralized DRM systems contribute prescriptive solution design knowledge that may help IS developers and music industry experts to co-design more effective solutions. This may also inform future DSR studies who wish to take our design further, either by implementing such a design in the music industry or by customizing it to related media industries.

Foundations

We reviewed the literature on DRM systems in the music industry and blockchain-based DRM systems in parallel (as explained in section "Rigor Cycle") to identify key issues in these respective domains. These issues are summarized in Table 1 and elaborated in the Introduction, the following subsections, as well as the respective sections on design requirements and design principles for decentralized DRM systems.

DRM systems in the music industry

In the music industry, the main challenge with DRM-enabled per-use payout has been that music rights and associated royalty licensing and payout processes have become increasingly complex, intransparent, and inefficient. Any piece of music today has various owners and rights, and music rights metadata is dispersed across various databases operated by many intermediaries (Crosby et al., 2016). As none of the existing centralized DRM systems can offer a global rights repertoire, rights owners have to access many databases across various intermediaries, increasing the risk of inconsistent and incomplete data (O'Dair, 2016). This larger issue relates to the lack of metadata exchange standards throughout the music value chain (Penick, 2018). In response, the Transparency of Music License Ownership Act was proposed to the US House of Representatives in 2017 as a bipartisan effort to address this lack of standards (Coalition, 2018; Flanagan, 2017), but has

Table 1 Key issues in relevant literature domains

Domain	Relevance	Key issues	Key sources
DRM systems in the music industry	Informs our generalized problem understanding by strengthening our design requirements	• Existing DRM systems are centrally controlled by major publishers and labels • Traditional DRM systems focus on enforcing use restrictions through watermarking, which can counterproductively reduce sales and restrict even legal users • More productive pay-per-use streaming models are complicated by complex and intransparent music licensing structures, incomplete and inconsistent metadata, as well as inefficient and intransparent royalty payout	(Baym et al., 2019; Beaumont-Thomas & Rushe, 2017; Bhattacharjee et al., 2009; Brooke, 2014; Burkart, 2008; De León & Gupta, 2017; Foroughi et al., 2002; Gebert, 2020; Gordon, 2015; Graham et al., 2004; Hardy, 2014; Koh et al., 2019; Kretschmer et al., 1999; Kwok et al., 2003; Lynch, 2001; Pitt, 2016; Riemer & Johnston, 2019; Vernik et al., 2011; Zhang, 2018)
Blockchain-based DRM systems	Informs our prescriptive solution design knowledge by strengthening our design principles	• Blockchain is a relatively new technology. Related legal, political, and regulatory frameworks are in their infancy or non-existent • Most novel blockchain-based DRM systems mirror the use restrictions of conventional systems, which have been shown to be counterproductive • Effective designs, informed by the practical business problems on the music industry, have yet to be discovered • An integrated solution needs to target the key business problems of the music industry	(Bakos et al., 2021; Chong et al., 2019; Finck & Moscon, 2019; Gao et al., 2021; Garba et al., 2021; Guo et al., 2020; Halgamuge & Guruge, 2022; Heap, 2017; Helliar et al., 2020; Janssen et al., 2020; Kapsoulis et al., 2020; Kim & Kim, 2020; Li et al., 2021; Lovett, 2020; O'Dair, 2016; Oyelude, 2022; Perez, 2018; Ramani et al., 2022; Savelyev, 2018; Zhao & O'Mahony, 2018)

not yet been passed at the time of writing. As a consequence of this legal vacuum, over one billion US dollars in royalties are left unallocated every year—withheld by major publishers due to technical difficulties of matching royalties to rights owners (Beard et al., 2017; Domingo, 2018). This has become known as the "value gap."

For over two decades, numerous prior attempts to close the value gap with centralized DRM systems have all failed. This is largely due to a lack of collaboration, a fear of becoming redundant, and incongruous stakeholder interests among major labels and publishers, who have a financial incentive to maintain the status quo that legally allows them to withhold royalties for music rights they do not own (Creative Edwards, 2016; Hardy, 2014; Industries, 2014). For instance, launched in 1998 by established music organizations in the USA, UK, and the Netherlands, the International Music Joint Venture was the first attempt to establish a global rights database. It dissolved in 2001, representing less than 21% of the global repertoire, after labels and publishers refused to participate from fear that releasing their repertoire would threaten their status and profitability (Hardy, 2014). Similarly, the International Music Registry, launched in 2011 by the United Nations, collapsed due to internal power struggles between labels and publishers (Hardy, 2014). More recently, the Global Repertoire Database, an initiative involving 80 organizations including Apple, Amazon, Google, as well as various publishers and labels, failed in 2014 after key organizations withdrew their financial support (Creative Edwards, 2016; Industries, 2014).

Blockchain-based DRM systems

To date, neither the legal frameworks nor centralized DRM systems provide an adequate solution to the abovementioned complex business problems of the music industry. We argue that, despite recent enthusiasm to decentralize DRM systems with blockchain technology (Baym et al., 2019), this decades-old problem will likely persist due to two interrelated root causes: lacking understanding of the music industry's business problems among blockchain developers, and lacking understanding of the blockchain technology by music industry experts. Hence, we briefly introduce the key features of blockchain technology before we review the related literature on blockchain-based DRM systems and their current challenges.

Blockchain refers to an append-only database shared by a decentralized network of computers that collectively validate the data, enabling many opportunities for decentralized value creation via business rules embedded in smart contracts (Beck et al., 2018; Lumineau et al., 2021). A smart contract is a self-executing computer program that algorithmically enforces contractual clauses once pre-programmed conditions are fulfilled (Szabo, 1997). Legal scholars of information and technology law have proposed that smart contracts could potentially increase the transparency and efficiency of royalty payout for IP rights (Bodó et al., 2018; Gebert, 2020). A blockchain can have different access configurations with regards to who can read data, who can submit new data, and who can validate data before it is written irreversibly into the blockchain (Helliar et al., 2020; Rossi et al., 2019):

- A *public-permissionless* blockchain allows all nodes to read data as well as to submit and to validate data. This is the most open type of blockchain, with Bitcoin as a prominent example.
- A *private-permissioned* blockchain allows only preauthorized nodes to read, submit, and validate data. This is the most restricted type of blockchain, with IBM Hyperledger Fabric as a prominent example.
- A *public-permissioned* blockchain sits in between, allowing all nodes to read the data and submit information to the blockchain, yet only preauthorized nodes to validate the information going into the blockchain. That is, only preauthorized nodes can submit and validate transactions.

Moreover, a blockchain requires a consensus mechanism to encourage the nodes to validate new transactions and to discourage them from creating inconsistent records of transactions (Bano et al., 2019):

- The proof-of-work (PoW) consensus mechanism requires nodes to solve computationally expensive cryptographic puzzles, with Bitcoin and the original Ethereum blockchain as prominent examples. PoW is associated with high economic cost, high energy consumption, and slow performance, but offers greater openness. It only works on permissionless blockchains.
- The proof-of-stake (PoS) consensus mechanism privileges validator nodes with higher cryptocurrency balances (= larger stakes) and rewarding or punishing them for desirable or malicious behavior, respectively. Compared to PoW, PoS is considered to be more economically efficient, less energy-intensive, and faster, but it potentially limits openness. PoS can theoretically operate on both permissioned and permissionless blockchains but are in practice mostly used on permissionless blockchains.
- The practical byzantine fault tolerance (PBFT) algorithm is an advanced consensus mechanism that uses high-performance Byzantine state machine replication (Castro & Liskov, 1999). It is capable of processing thousands of transactions per second while also maintaining high levels of robustness. PBFT is more economically efficient and faster than PoW and PoS but requires a permissioned blockchain (Bano et al., 2019).
- There are many other consensus mechanisms, which are however beyond the scope of this paper (for an overview see Bano et al., 2019).

Furthermore, stablecoins can reduce or eliminate the price volatility of conventional cryptocurrencies (such as Bitcoin) by pegging their value to another asset, typically a fiat currency such as the US Dollar. The peg can be maintained in two ways (Eichengreen, 2019; Lyons & Viswanath-Natraj, 2020):

- *Collateralized pegging* is the most common and tested form of pegging. It is achieved by a central entity maintaining equal reserves of cryptographic tokens and a collateral of the pegged asset. In practice, collateralized stablecoins almost always use fiat currency or cryptocurrency as collateral. For instance, Tether is the most widely used stablecoin maintaining a one-to-one peg to the US Dollar through demand-side arbitrage. That is, Tether Holdings Limited issues or redeems Tethers—cryptographic tokens—for the respective deposit or withdrawal of US dollars to or from a regularly audited bank account. Whenever the price of one Tether raises above or falls below that of one US Dollar, users have an incentive through this demand-side arbitrage mechanism; Tether has so far maintained its peg to the US Dollar successfully, even throughout economic downturns.
- *Non-collateralized pegging* is achieved by using algorithms to control the currency supply, similar to a central bank creating or destroying currency when the peg is broken, as is the case with the Danish Kroner peg to the Euro. Because an algorithm can maintain the peg rather than a central entity, non-collateralized pegging may be more economically efficient and more decentralized than collateralized pegging but has so far been much less resilient during market turmoil. The reasons for this are unclear, but it might be because stablecoins do not enjoy the same level of societal trust as central banks, or perhaps simply because the existing human-made computer algorithms are flawed.

A review of the literature suggests that various conceptual designs for blockchain-based DRM systems have been proposed recently, as listed in the bottom-right cell of Table 1. Nearly all of these designs share the assumption that DRM systems should provide IP protection through content watermarking and algorithmic enforcement of usage restrictions (Finck & Moscon, 2019; Gao et al., 2021; Garba et al., 2021; Guo et al., 2020; Halgamuge & Guruge, 2022; Kapsoulis et al., 2020; Kim & Kim, 2020; Li et al., 2021; Zhao & O'Mahony, 2018). This misses the aforementioned key business problems of the music industry, where DRM-enabled IP protection has been shown to be counterproductive (Zhang, 2018). Notable exceptions include Ramani et al. (2022), whose conceptual design includes content sharing and royalty payout. However, this design also focuses predominantly on IP protection and provides limited guidance for addressing metadata inconsistency and complex licensing structures. It also lacks specific guidance for designing the royalty payout mechanism. Gao et al. (2021) propose a peer-to-peer rights trading scheme that focuses on privacy and economic incentives for royalty payout, however, without considering complex licensing structures and metadata inconsistency.

Overall, these recently proposed designs are unlikely to be adopted by the music industry, given the long history of mistrust and lack of collaboration among major organizations. Social and institutional issues in the music industry have hindered adoption of blockchain-based DRM, including lack of governance and trust among stakeholders as well as lack of trust in the technology (Baym et al., 2019). These are typical barriers to blockchain adoption (Janssen et al., 2020; Völter et al., 2021). As Savelyev (2018) puts it, blockchain can only fulfill its promise of decentralization if it provides an integrated solution to the music industry's business problems regarding licensing, metadata, and royalty payout. The complexity of international copyright law demands an architecture for blockchain-based DRMs that allows to align smart contracts with jurisdictional privileges of state authorities while also providing economically viable mechanisms to maintain consistent metadata and royalty flows to ensure necessary network effects.

Methodology

We position our study within the design science research (DSR) paradigm (Peffers et al., 2007). DSR studies extend human and organizational capabilities by solving a practical problem and extracting prescriptive knowledge from that, thereby contributing generalized abstractions from the problem and solution (Hevner et al., 2004; Thuan et al., 2019; van Aken, 2004). Our aim is to provide guidance and orientation for decentralizing DRM systems, given the complex issues of DRM, the long history of failures of DRM systems in the music industry, the prohibitive cost of implementing such a large-scale socio-technical system, and the immaturity of blockchain technology and related regulatory frameworks. Hence, our DSR study is exploratory in nature, and we were inspired by Hevner and Gregor's (2020) idea to envision digital innovations via a DSR lens. We structure our DSR activities consistent with Hevner's (2007) mutually intertwined three cycles, as illustrated in Fig. 1 and explained below: (1) design cycle; (2) relevance cycle; and (3) rigor cycle.

Design cycle

As the center of Fig. 1 shows, we used scenario-based design (Rosson & Carroll, 2009) to describe the concrete problems and potential solutions of DRM systems in context. Scenarios contain rich descriptions with contextualized implicit knowledge, such as goals and characteristics of users, typical tasks they engage in, the tools they use, and their organizational context. A scenario consists of a setting, one or more actors with personal motivations, knowledge and capabilities, and various tools that the actors encounter and use. The scenario describes a sequence of actions and events that lead to an outcome (Rosson & Carroll, 2009).

As shown on the left side of Fig. 1 and elaborated in section "Relevance cycle," we used qualitative methods to describe the contextualized problem in its environment and to identify design requirements. A *design requirement* is a generalized description of the needs and the goals a class of systems should attain to address a class of problems, ensuring a close mapping between the specific problem in context and the general body of knowledge about the problem (Walls

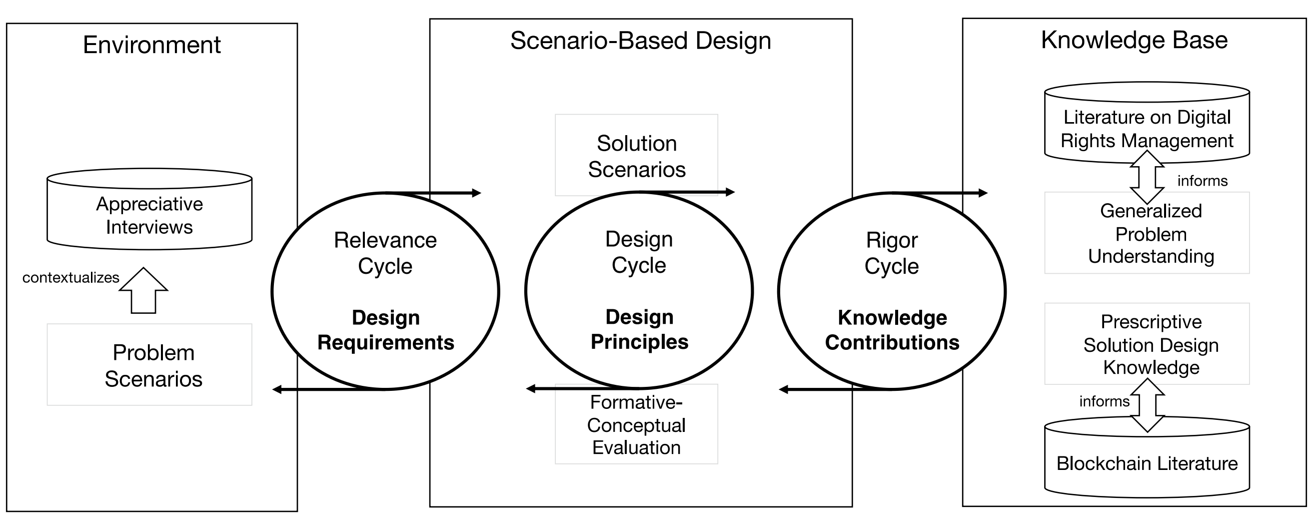

Fig. 1 Exploratory DSR approach

et al., 1992). We contextualized the design requirements via problem scenarios to provide a detailed problem understanding obtained in a real-world setting. Problem scenarios describe prototypical human actors engaged in meaningful activities, highlighting features of current practice that have important consequences for the actors (Rosson & Carroll, 2009). We frequently revised the design requirements and problem scenarios through dialogical iterations between our empirical data, extant literature, and feedback obtained through our evaluation (as below).

We then combined our design requirements with extant literature on the general problem and solution to identify design principles. A *design principle* is a generalized description of prescriptive knowledge on how to attain a solution that can solve a class of problems (Gregor & Jones, 2007). As such, design principles underline the actors in a process, the functionality that the process attempts to achieve, the given specific or general context, and finally the outcomes of the design principle (Gregor et al., 2020). Design principles can guide the design of a class of systems (e.g., not a specific DRM system but *all* DRM systems) that in turn correspond to the set of general design requirements. Because validating DRM systems entails a risky and unfeasible scale of implementation at the industry level, we contextualized the design principles via solution scenarios to envision how current activities might be enhanced or transformed by our solution (Rosson & Carroll, 2009). Given these domain constraints, the solution scenarios acted as instantiations of our design principles.

We then evaluated the design principles to validate their accessibility, importance, novelty, actability, and effectiveness (Iivari et al., 2020) in unison with the solution scenarios. Evaluation is an important DSR activity to establish validity and credibility of DSR outputs (Prat et al., 2015; Venable et al., 2016). There are many approaches depending on the context of use and type of technology, ranging from formative to summative evaluation and from conceptual to empirical evaluation (Venable et al., 2016). Low adoption and insufficient regulation of blockchain in the music industry (EuropeanCommission, 2020), as well as resistance from established organizations in the music industry (Creative Edwards, 2016; Hardy, 2014; Industries, 2014), meant that a summative-empirical evaluation would be prohibitively risky, expensive, and infeasible, so we opted for a formative-conceptual evaluation (as proposed by Venable et al., 2016).

Design principles and scenarios are ideal for formative-conceptual evaluations, as they are sufficiently rich and contextualized to let experts judge whether the design could solve an important business problem in a feasible and desirable way (Gregor et al., 2020; Hevner & Gregor, 2020). Evaluation of design principles is particularly appropriate when authors wish to take ownership of their design principles *before* the technology becomes widely available and adopted (Iivari et al., 2020). Accordingly, design principles are foundational to our evaluation, as blockchain technology has not been widely adopted in the music industry and legal and regulatory frameworks are in their infancy (EuropeanCommission, 2020).

We used the questionnaire template proposed by Iivari et al., (2020, pp. 303–304), which we sent out to ten experts who all filled out the survey. Three of them also shared feedback in a qualitative interview of one hour each. Among the ten experts, four were previously interviewed to identify the design requirements (as described in section "Relevance cycle") and six were newly recruited. This enabled us to validate the design requirements and principles with experts who are directly exposed to the problems with existing DRM while also obtaining qualitative feedback from experts who were not previously interviewed. Of these six, three previously approached us directly with feedback on an earlier conference version of this paper, and the remaining three were recruited via our LinkedIn network. We took care to draw a broad sample of respondents with diverse perspectives on the business and technological aspects of digital music rights management. The experts all had comprehensive experience and knowledge in this field. Six respondents had worked in the music industry for more than 10 years, two respondents had more than 5-year experience, and two respondents had less than 4-year experience in the music industry. On average, the respondents were 39 years old. For contextualization of the design principles, we included our problem and solution scenarios for the participants to read prior to filling out the questionnaire. Appendix Table 6 provides our full evaluation protocol and the main results.

Relevance cycle

The relevance cycle bridges the design and evaluation activities with the contextual environment of the research project to identify design requirements (Hevner, 2007). We used qualitative methods to gain insight into the various perspectives of music industry experts, as well as the social and cultural contexts within which they work (Myers & Avison, 2002; Olsen & Pedersen, 2018). Interviews allowed us access to the respective perceptions and interpretations of participants that are deeply immersed in a phenomenon (Klein & Myers, 1999).

Since various stakeholders are involved in DRM systems, we chose a diverse and purposive sample (Eisenhardt & Graebner, 2007) to identify the design requirements. We interviewed ten music industry experts in the UK, USA, Canada, Finland, and Denmark, with representatives from both the established music industry and from blockchain start-ups. One author conducted the interviews, ranging from 30 to 90 min (60 min on average), out of which two were via phone, two via video call, and six in person. Another author provided guidance and mentoring. This allowed us to engage deeply with the experts while maintaining a critical distance through weekly meetings to discuss the emerging findings. Table 2 provides an overview.

As shown in Table 1, we interviewed four experts at ABC, which serves music copyright societies and their members by ensuring that money is collected and distributed to the rights owners on behalf of the music copyright societies. We also interviewed one expert at sound, which ensures remuneration from YouTube content, building system interfaces to the various intermediaries, as well as identifying, collecting, and distributing royalties. We interviewed an executive manager of Nuotit, which collects and distributes royalties on behalf of composers, publishers, musicians, and arrangers. We interviewed the executive manager of AUX, which is a start-up focused on creating a blockchain that will allow the music and media industry to collaborate on a global view of content ownership and rights. We interviewed one co-founder at VOIX, which is a start-up that creates smart contracts, based on the Ethereum blockchain, for transactions, focused on P2P music sharing between artists and consumers. Furthermore, we interviewed a musician who has worked in the industry for 10 years, publishing 15 EPs, singles, and albums, and starting two of his own labels. He provided an insight into the challenges artists perceive in the music industry. We also interviewed a music manager who has worked for a major label to obtain insights into challenges within established firms from a managerial perspective. All participants were pseudonymized to respect their privacy (Walsham, 1995).

We used the appreciative interviewing technique to let participants describe their past experience and envision desirable futures (Schultze & Avital, 2011). Our semi-structured interview protocol (Appendix Table 5) ensured consistency across interviews while also allowing participants to freely express their views. In line with the appreciative interview technique, the interview protocol included positive prompts to encourage reflection on opportunities for improvement; it also included open-ended questions to encourage reflection outside this framing (Schultze & Avital, 2011). This was important to counter the risk that participants unreflectively repeat well-known concepts and jargon. Finally, the interview protocol was designed to let participants reflect on their current challenges with DRM systems, as well as to envision better practices.

We used coding (Gioia et al., 2013) to analyze the interview transcripts for challenges and opportunities of decentralized DRM systems. We transcribed the interviews using a denaturalized approach, which focuses on the substance of the meanings and perceptions provided in the interview rather than depicting accents or involuntary vocalization (Oliver et al., 2005). After cross-checking the transcriptions, one author performed initial data coding to identify informant-centric concepts, which two authors then together grouped into a comprehensive compendium of empirical themes (Gioia et al., 2013), as shown on the left-hand side of Fig. 2. Next, the two authors organized these empirical themes into eight theory-centric conceptual categories by aggregating them and connecting them with extant literature (Gioia et al., 2013), as shown in the middle of Fig. 2. Finally, the two authors distilled the conceptual categories into three overarching aggregate dimensions (Gioia et al., 2013), as shown on the right of Fig. 2. These became the focus of our subsequent design activities.

Rigor cycle

The rigor cycle is tightly intertwined with the relevance and design cycles to strengthen the validity and credibility of DSR outputs by connecting them to the existing knowledge base (Hevner, 2007). In addition to rigorously applying scenario-based design methods and qualitative methods (as above), we also established rigor by closely connecting our emerging findings to existing knowledge about the problem and solution.

Table 2 Overview of interviews

#	Role	Organization	Location	Duration	Gender	Type
I1	Executive manager	AUX	UK	30 min	Male	Skype
I2	Business expert	ABC	Denmark	1 h	Male	F2F
I3	Music manager	Independent	Denmark	1 h	Male	F2F
I4	Business expert	Sound	Denmark	1 h	Male	F2F
I5	Executive manager	ABC	Denmark	1 h	Female	F2F
I6	General manager	ABC	Denmark	1 h	Male	F2F
I7	Executive manager	Nuotit	Finland	30 min	Male	Phone
I8	Executive manager	Voix	Canada	1 h	Male	Skype
I9	Musician	Independent	US	30 min	Male	Phone
I10	Music manager	ABC	Denmark	1 h	Female	F2F

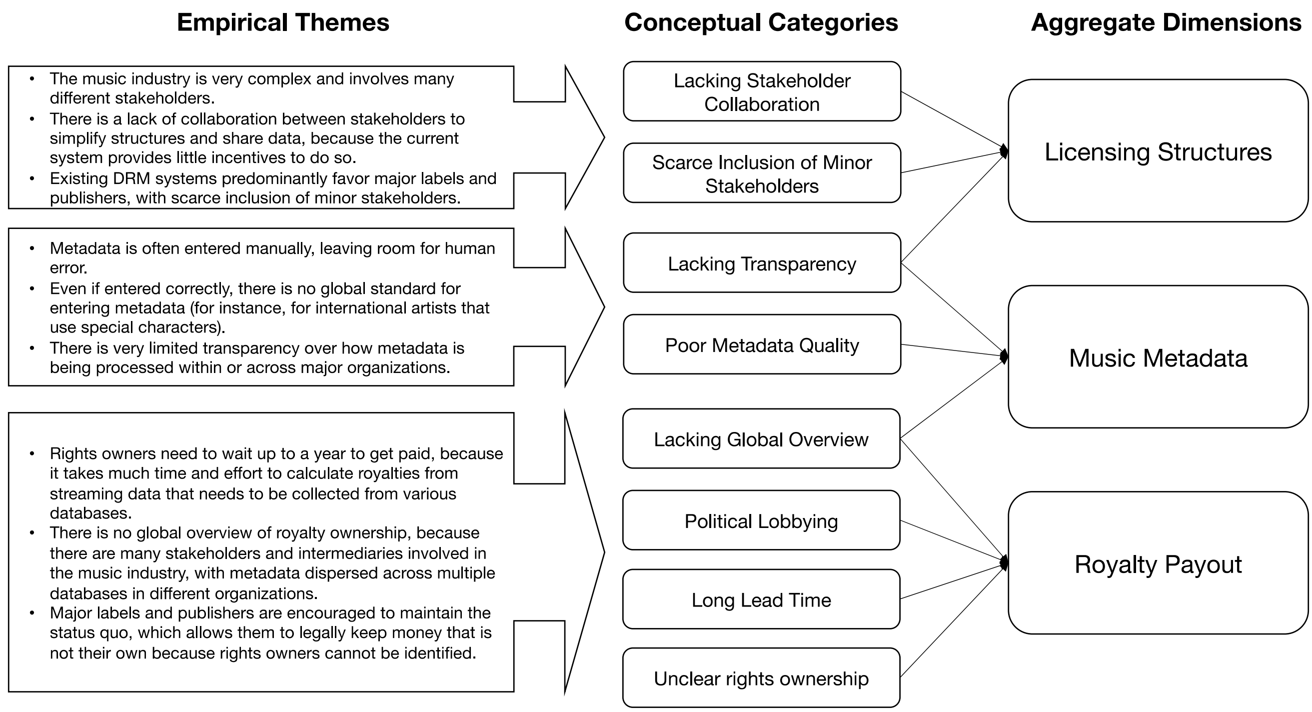

Fig. 2 Overview of coding

We iterated between design requirements, design principles, and extant literature to grow our understanding of the problem while also providing orienting frameworks for data collection and analysis in subsequent theorizing (Vom Brocke et al., 2015). For example, we structured each design requirement according to a general problem confronting DRM systems, evidenced both by extant literature and our qualitative data. Accordingly, we connected each design principle to a design requirement (Meth et al., 2015).

To connect our emerging findings to the knowledge base (Hevner, 2007), we conducted a hermeneutic literature review (Boell & Cecez-Kecmanovic, 2014). We initially searched on Scopus and Google Scholar using the keywords "music," "digital rights management," "blockchain," "distributed ledger technology," and "digitization," as well as variations thereof. We selected relevant literature through orientational reading to gain an overall impression (Boell & Cecez-Kecmanovic, 2014). Furthermore, as the literature on both blockchain and DRM systems is in a nascent stage, we used snowballing (Boell & Cecez-Kecmanovic, 2014) to find further relevant literature in related contexts (e.g., DRM systems in other media industries). In line with our deepening understanding of the literature and empirical data, we periodically screened the literature throughout the 3-year duration of the research project using the query (("digital rights management" OR "digital music rights management") OR (blockchain AND music)) to search in 847 relevant journals with the help of litbaskets (Boell & Wang, 2019). In all, we identified 19 relevant papers on digital music rights management and 14 relevant papers on blockchain (as listed in the right-most column of Table 1), which we used to strengthen our design requirements and design principles, respectively.

We also considered grey literature alongside peer-reviewed academic papers, because of the rapidly evolving nature of blockchain and digital music. We used Google Scholar to acquire industry reports, press releases, practitioner journal articles, and opinion pieces from reputable news sources, industry consortia, and internationally recognized music industry experts. We excluded grey literature of low quality in terms of lack of methodological transparency, lack of compelling evidence to support opinions, lack of a clear problem addressed with a proposed technological solution, or lack of verifiable credentials of the author(s). This was important due to the abundance of low-quality articles on blockchain-based DRM appearing on Google Scholar.

We analyzed the sampled papers for key issues with existing DRM systems to inform our generalized problem understanding and to strengthen our design requirements. In parallel, we analyzed the sampled papers for opportunities and challenges posed by blockchain technology in general and blockchain-based DRM systems in particular to inform our prescriptive solution design and strengthen our design principles. For instance, we problematize the key issues with existing DRM systems (both conventional and blockchain-based) in the introduction and foundation sections, and we discuss the sampled papers in detail in the following section on design requirements for decentralized DRM systems (with a business focus on digital music rights management), as well as the section on design principles thereafter (with a technical focus on blockchain).

Design requirements for decentralized DRM systems in the music industry

We now analyze the current challenges and practical problems of digital music rights management, from which we develop three design requirements for decentralized DRM systems in the music industry. We develop each design requirement from an analysis of extant literature and our empirical data. Table 3 provides an overview, and the ensuing sections provide detailed analyses.

DR1: Transparent music licensing structures

The management of IP, licenses, and royalty payouts is built on pre-Internet structures with many intermediaries. The evolution to on-demand music streaming, together with the absence of a global rights database, has resulted in the development of complex, error-prone, and time-consuming licensing structures.

Although music business models increasingly rely on Internet technologies (Crosby et al., 2016; De León & Gupta, 2017; Graham et al., 2004; Warr & Goode, 2011), the handling of IPs, licenses, and royalty payouts still follows outdated structures from the pre-Internet era (De León & Gupta, 2017; O'Dair, 2016). Because there is currently no international consensus on the scope, duration, and enforceability of IP rights, every individual music right could legally be enforced differently in every single jurisdiction (Bodó et al., 2018). There are typically two types of music rights associated with any given song: recording rights and composition rights. Publishers obtain composition rights whereas recording rights remain with a record label that typically also owns the master recording. Publishers and labels are responsible for registering the rights with a performance rights organization, such as PRS in the UK or GEMA in Germany. These administer the rights and collect royalty payouts from various digital service providers (such as iTunes, Spotify, or YouTube) to remunerate the rights owners. Royalty payouts work differently for recording and composition rights, as these may have different organizations assigning an international standard recording code to the recording right and an international standard musical work code to the composition right (Beaumont-Thomas & Rushe, 2017).

As performance rights organizations represent a wide range of artists, they often commission a back-office agency to collect royalties and a payout agency to process usage files from the digital service provider to calculate the royalty payout for individual rights owners. Digital service providers need to obtain different licenses from performance rights organizations to offer music through their platforms, which involves both a mechanical license for downloading and a performance license for streaming (Pitt, 2016). As users can stream a piece of music without downloading it, the digital service provider also needs to apply for a performance license and agree on a percentage split between the two licenses. Additionally, direct licensing allows digital service providers to enter into a bilateral agreement with labels, bypassing collecting agencies and performance rights organizations to save fees (Pitt, 2016). However, direct licensing agreements are usually not tied to a specific work, but an entire catalog, often leaving rights unallocated and owners unpaid (Gordon, 2015).

Our interviews showed that complex licensing structures pose a major challenge for rights owners as well as

Table 3 Design requirements for DRM systems in the music industry

Design requirement (DR)	Rationale
DR1: A decentralized DRM system for the music industry must provide transparent music licensing structures	The management of IP, licenses, and royalty payouts are built on pre-Internet structures with many intermediaries. The evolution to on-demand music streaming, together with the absence of a global rights database, has resulted in the development of complex licensing processes over time, which are error-prone and time-consuming
DR2: A decentralized DRM system for the music industry must ensure consistent and complete music rights metadata	Music rights metadata is dispersed across many intermediaries' databases in inconsistent and incomplete format, complicating the allocation of royalties to rights owners. Various organizations in the music industry currently maintain separate databases, leading to inconsistent and incomplete music metadata
DR3: A decentralized DRM system for the music industry must enable efficient and transparent royalty payout	Complex licensing structures and dispersed metadata lead to massive delays in the payout of royalties to rights owners, with one billion US dollars annually unallocated. This makes it very difficult to accurately map music usage data to rights owners, leading to royalty payout processes that are inefficient and lacking in transparency

performance rights organizations that calculate royalties. Licensing was straightforward in the age of the CD, where compensation would relate to the number of CDs sold, and complete metadata had to be in place before a label would release a CD. But in today's streaming-dominated world, artist compensation is calculated on a per-stream basis, based on large and unstructured files, rendering the allocation process complex and resource-consuming. As one participant explained:

> It's always two challenges that have been on the market since online began: [...] volume and the complexity of direct licensing. [...] There are 10 other units who are doing the same, so we are taking the same file, multiplying 15 times, and having the 15 servers doing that [processing] in order to find our different parts and bits that we want to invoice. (I2, Business Expert, ABC, DK).

The structures for sharing the files are often outdated. Sending data files back and forth between different societies and countries, as well as having multiple organizations working on the same data file is a vestige of the past structure of the music industry, as one participant explained:

> You have 20 different societies in Europe processing exactly the same data from all over Europe plus 10-15 publishers. [...] That means that the same amount of data is being transported every month [multiple] times, instead of just having one repository that you query every time you get something new, so there is a lot of overhead (I4, Business Expert, Sound, DK).

These outdated structures prevent a global solution. A participant explained:

> "I don't see [the music industry] growing with the amounts of bad data and enormous data files." (Translated from I5, Executive Manager, ABC, DK).

The challenges with mapping music metadata lead to complex licensing structures, due to the absence of a comprehensive global rights database. Not only does this result in error-prone and inefficient processes, but in considerable royalties withheld from rights owners, as digital service providers and TV/radio stations can legally refuse to pay for an incorrectly mapped repertoire. Hence, we suggest that a decentralized DRM system for the music industry must provide transparent music licensing structures.

DR2: Consistent and complete metadata

Music rights metadata is dispersed across many intermediaries' databases in inconsistent and incomplete format, complicating the allocation of royalties to rights owners (Brooke, 2014; Gebert, 2020; Molinder, 2018). Various organizations in the music industry currently maintain separate databases, leading to inconsistent and incomplete music metadata. Music rights metadata describe split deals between different entities and are thus crucial in the licensing process. Metadata typically includes song title, performing artist, year of release, composer, producer, publisher, physical retailers, digital service providers, performance rights organizations, and record labels (Brooke, 2014). It is vital to organize metadata in a way that enables easy access for relevant parties in the royalty payout process (Brooke, 2014).

Organizing performance rights metadata was straightforward in the pre-digital age, where all artist and composer data had to be in place before, for example, a CD could be produced. Presently, a song can be uploaded to various digital service providers within minutes without complete or consistent data, making remuneration difficult or impossible because performance rights organizations and collecting agencies cannot allocate a specific work to its respective rights. Additionally, a performance rights organization typically receives metadata from composers and artists and then enters it into its system manually, allowing for human error. An example is composer Tchaikovsky, whose name is spelled in over 70 different ways (MusicBrainz, 2020).

Our interviews showed that inconsistent and incomplete music rights metadata is a pervasive problem with far-reaching consequences. When data is manually entered into databases spread across multiple intermediaries, there is a lot of room for human errors causing incompleteness or inconsistency of metadata. Complicating matters, there is no single point of truth or universally agreed-upon standard, making errors difficult to detect and correct. Several participants explained:

> It is still very unstructured. [The music industry] is built on the ideas that you take the old world and make it digital but through the same standards. And this is where the challenges occur. You need to be sure what is actually being played and this requires good data. (Translated from I5, Executive Manager, ABC, DK).
> One of the biggest problems within the industry is that the work information and the actual recording information are not connected. There is a metadata problem. The music industry lacks standards that would make the business more powerful. (I7, Executive manager, Nuotit, FIN).

In addition to spelling errors, poor quality metadata can also result from rights owners not revealing their share of a composition or recording as well as, conversely, claiming rights to compositions or recordings that they do not in fact own. This happens frequently after a company merger or acquisition, whereby the metadata is typically not transferred correctly and completely. As one participant explained:

> [In the] streaming top 100, there are 5 million reported tracks, 42% [of them] are missing composer/author titles. A third of all commercially relevant tracks still have no Composer/Author information." (I4, Business Expert, Sound, DK).

Without an industry-wide collaboration on metadata standards, artists and composers are often left empty-handed. Unfortunately, uncertainty about the responsibilities and governance of a global system pose barriers to such an industry-wide collaboration, as explained by two participants:

> New technology is great but who is going to pay for it? [...] Is it the studio's responsibility to take note when they do the master recording and send it to the label and then they send it through aggregators? I mean who has that [responsibility]? We don't know. [...] How do they grab that data and how do they transmit it? That's the big question. (I4, Business Expert, Sound, DK).
> Who should control this system and who will benefit most from it? (I2, Business Expert, ABC, DK).

The above illustrates the challenges associated with sending music metadata to different organizations and the manual entry of data into databases. Hence, we suggest that a decentralized DRM system for the music industry must ensure consistent and complete music rights metadata.

DR3: Transparent and efficient royalty payout

Complex licensing structures and dispersed metadata lead to massive delays in the payout of royalties to rights owners, with one billion US dollars annually unallocated (Beard et al., 2017; Cooke, 2015; Domingo, 2018; Kostaras, 2016). By some estimates, this corresponds to about a quarter of all music royalties (Molinder, 2018). This makes it very difficult to accurately map music usage data to rights owners, leading to royalty payout processes that are inefficient and lacking in transparency.

It is possible to bypass labels and publishers in making royalty payments by using digital aggregators, such as AWAL and Kobalt, which allow artists to retain ownership of their master recording and receive royalty payouts by distributing their works through digital stores and streaming platforms. However, as of 2015, 37% of musicians were signed to record label deals that do not consider digital revenues (Cooke, 2015), remuneration of artists in a way that reflects online streaming structures is difficult. Complicating matters, digital service providers are not legally responsible for unlicensed content uploaded by their users, although they must compensate the rights owners or remove content when it is found to be infringing (Beard et al., 2017). However, studies show that digital service providers fail to recognize two out of five infringements (Kostaras, 2016), resulting in a revenue loss of over one billion US dollars a year in the USA alone (Beard et al., 2017). This incongruity between the value online services extract from music and the revenue returned to the music community has become known as the "value gap" (Domingo, 2018).

Our interviews showed that the challenges of metadata and licensing structures often create a lack of transparency and lead to inefficient royalty payouts. Insufficient metadata causes uncertainty regarding payment, resulting in the wrong people—or no one—getting paid. One participant explained:

> We also have a lot of royalties not being paid out because the work documentation is not sufficient. [...] When we receive a usage report, we cannot identify all the lines in the report correctly. (I6, General Manager, ABC, DK).

As organizations need to access different databases, they lack a complete repertoire. As a result, metadata and royalties are withheld within various organizations. Additionally, the manual handling of data is error-prone, as music managers and different intermediaries all manually enter data in their respective system:

> There is a lot of room for error. Even though we spend so much time to register our albums [...] it just doesn't get shared. You know someone is getting a list and they are typing it off, which for me is just completely insane. (I3, Music Manager, Independent, DK).
> [It is] usually the youngest interns [entering the data], who don't know what they're doing. (I4, Business Expert, Sound, DK).

The above illustrates the challenges associated with a lack of transparency in the royalty payout process. Finding and correcting errors in music metadata is a challenging and time-consuming task, as rights owners need to contact many different organizations to locate the problem. Moreover, because of the problems associated with complex licensing structures, it can take a long time to detect and correct errors. Hence, we suggest that a decentralized DRM system for the music industry must enable efficient and transparent royalty payout.

Design principles for decentralized DRM systems in the music industry

Having established the design requirements, we now develop and evaluate three corresponding design principles for decentralized DRM systems in the music industry. Table 4 provides a summary and elaborations follow.

DP1: Store public metadata on a distributed ledger

A public blockchain facilitates transparent music licensing structures by storing music metadata on a distributed ledger that everyone can read. Since the metadata also includes information about licensing structures, who holds the rights to receive royalties from performance or mechanical licenses (such as composers, artists, producers), storing music metadata on a distributed ledger makes licensing structures transparent. Hence, we suggest the following design principle.

DP1: A decentralized DRM system for the music industry should store music rights metadata on a distributed ledger using a public blockchain to make licensing structures transparently visible to everyone, so that rights owners can claim royalties

Storing music metadata on a public blockchain would make licensing structures transparent. Two participants state that a shared platform for handling music licenses would be highly desirable:

> If everybody could share their information into the same engine it would make everybody's life much easier. (I3, Music manager, Independent, DK).
> For me, this is what could make it beneficial to have one [database], where the artists would register their data and have control of that data, and this is what you would integrate into when you need to payout royalties. [...] The artists get more transparency in regard to their data uploaded there. (Translated from I5, Executive Manager, ABC, DK).

Some participants argue that decentralized DRM could be beneficial for the entire music industry, pending a balance between transparency and discretion. As one participant explains:

> If you make it completely open who owns what and your deals with the rights owner, then it becomes very easy for others to come in and provide an offer and steal that business. [...] I know that there were some ideas in relation to a closed blockchain, which might be something to start out with [but then] you create a lack of transparency again. (Translated from I5, Executive Manager, ABC, DK).

Consequently, the choice between a public or private blockchain emerges as an important design decision. Although a public blockchain would maximize transparency and allow everyone to contribute, it remains to be seen whether labels and publishers would participate in such a solution.

DP2: Validate metadata via a consensus mechanism on a permissioned blockchain

A permissioned blockchain facilitates professional validation of metadata to ensure its consistency and completeness. By validating music metadata through a consensus mechanism on a permissioned blockchain and assigning a unique identifier to rights owners, labels and publishers can ensure that the data is consistent and complete. Hence, we suggest the following design principle.

DP2: A decentralized DRM system for the music industry should validate music metadata with a consensus

Table 4 Design principles for decentralized DRM systems in the music industry

Design principle	Rationale
DP1. A decentralized DRM system for the music industry should store music rights metadata on a distributed ledger using a public blockchain to make licensing structures transparent to everyone, so that rights owners can claim royalties	A public blockchain facilitates transparent music licensing structures by storing music metadata on a distributed ledger that everyone can read. Since the metadata also includes information about licensing structures, who holds the rights to receive royalties from performance or mechanical licenses (such as composers, artists, producers), storing music metadata on a distributed ledger makes licensing structures transparent
DP2. A decentralized DRM system for the music industry should validate music metadata with a consensus mechanism on a permissioned blockchain and assign a unique identifier to rights owners, so that labels and publishers can ensure consistency and completeness	A permissioned blockchain facilitates professional validation of metadata to ensure its consistency and completeness. By validating music metadata through a consensus mechanism on a permissioned blockchain and assigning a unique identifier to rights owners, labels and publishers can ensure that the data is consistent and complete
DP3. A decentralized DRM system for the music industry should algorithmically enforce royalty payouts with a smart contract to make payout processes more transparent and efficient, so that rights owners can receive royalties automatically in the form of stablecoin	A smart contract facilitates algorithmically enforced royalty payout. By relying on a single source of truth for music metadata, the smart contract enables the algorithmically enforced payout of royalties via cryptocurrency and provides an open interface for digital service providers, maintained by a consortium of labels, publishers, performance rights organizations, and digital service providers. A stablecoin provides price predictability

mechanism on a permissioned blockchain and assign a unique identifier to rights owners, so that labels and publishers can ensure consistency and completeness

Although music metadata would likely be more complete on a blockchain, compared to the various databases that exist today, the technology alone is not an adequate solution, as accurate information must still be manually entered into the database. Hence, music metadata must be validated to ensure consistency and accuracy. Additionally, incomplete entries must be detected, so that rights owners can check entries themselves. As one participant explains:

> The vast majority of conflicts are due to errors and missing data. So, what a blockchain will do is [to] aggregate everyone's data so hopefully the impact of missing data will be a lot less but also it will be able to highlight areas where there are doubts so people can come in and fix it. (I1, Executive Manager, AUX, UK).

A central design decision therefore is who to task with entering and validating the metadata. A blockchain without comprehensive music metadata is useless. As all music metadata today is spread across different organizations in different databases, integrating these datasets into one platform would be beneficial. However, initiatives to launch such a platform would have to consider that most existing music has already been released through a label or publisher. As two participants explain:

> For a platform, you also need the data and that's one of the problems. They don't have the data; they only have a platform and that's why they need to interact with the existing players who eventually have the data. (I7, Executive manager, Nuotit, FIN).
> You need to go to each rights owner to be able to license their content so if you are a young app developer and you want to create something that is legal, and you want to have content, then you have to get every single one. (I1, Executive Manager, AUX, UK).

In other words, while blockchain could ensure metadata consistency for new music, the support of labels and publishers, who hold licenses for existing music, would be crucial. For this to work, major labels would need to contribute their licensed music repertoire.

Therefore, an important design decision is whether the blockchain should be permissionless or permissioned. In the case of a permissionless blockchain, everyone could validate metadata. While this invites participation, it also introduces governance challenges, since a permissionless blockchain poses a risk to the integrity of records. Alternatively, a public-permissioned blockchain could be run by a consortium of labels, publishers, collective management organizations, and other stakeholders, which would have the exclusive right to validate the metadata that is entered by rights owners. We suggest such a permissioned configuration, as it can be more reliably governed, and therefore is more likely to ensure consistency and completeness of music metadata.

A related useful design feature to further support consistency would be a unique identifier for right owners (similar to ORCID for researchers). This would address the issue regarding artist names, as many personal names are not unique, they can change, or they can be spelled in numerous ways.

DP3: Algorithmically enforce royalty payout via stablecoin

A smart contract facilitates algorithmically enforced royalty payout. By relying on a single source of truth for music metadata, the smart contract automates the payout of royalties via cryptocurrency and provides an open interface for digital service providers, maintained by a consortium of labels, publishers, performance rights organizations, and digital service providers. A stablecoin provides price predictability. Hence, we suggest the following design principle.

DP3: A decentralized DRM system for the music industry should algorithmically enforce royalty payouts with a smart contract to make payout processes more transparent and efficient, so that rights owners can receive royalties automatically in the form of stablecoin

A decentralized DRM system with sufficient music metadata could make royalty payout transparent and efficient by utilizing a smart contract, which would enable automatic payout of royalties in the form of cryptocurrency. As one participant clarifies:

> Right now, you still have a stage period. You wait some time; you make an invoice. So, you are not close to having this in real time, I think that's where blockchain is the option. (I6, General Manager, ABC, DK).

An important design decision is what kind of cryptocurrency to use. One option would be to introduce a new, native cryptocurrency. While this could allow for greater flexibility in designing the smart contract, it could generate considerable overhead and barriers for adoption, as new markets would have to be developed where the native cryptocurrency is accepted as payment. Considering that over 10,000 cryptocurrencies currently exist (CoinMarketCap, 2020), we suggest using an existing cryptocurrency as explained below.

A closely related design decision is whether to use a conventional cryptocurrency (such as Bitcoin or Ethereum) or a stablecoin (such as Tether or USD Coin). Volatility has been a barrier to widespread adoption and use of cryptocurrency.

Stablecoins are better suited as a means of payment and as a (relatively) safe store of value. Therefore, we suggest using a stablecoin, as adoption would be more likely with such a solution.

Evaluation

As the formative-conceptual evaluation showed, music industry experts agree with the accessibility and importance criteria, indicating that the design principles address a real and important problem in the music industry in a way that is easy to grasp. One expert clarified:

> There's a real problem that needs to be solved across all the rights management platforms but there's a long way to go. Right now [PROs] don't even cross-validate their databases for song copyright registrations. [Respondent 2]

The combination of algorithmically enforced royalty payouts, transparency with built-in trust, and consistency of data was mentioned as a particularly useful and desirable aspect. One expert stated:

> As a musician, I would love to get better royalties for my streams but […] it's too much work to understand all the different aspects, so I really just rely on my manager for that. If there was an easier way for me as a musician to keep track of everything, I would be stoked. [Respondent 7]

While the participants, on average, agreed with the remaining criteria (novelty, actability, and effectiveness), the responses were more varied here. For instance, musicians and music managers, who were not previously familiar with the potential of blockchain to improve their practice, provided higher scores for novelty than those respondents who already work with such solutions. Conversely, technically knowledgeable respondents provided higher scores for actability and effectiveness than those respondents with business experience. This, in combination with the qualitative feedback we obtained, indicates that our design principles are feasible from a technical viewpoint, but from a business viewpoint, there are some challenges to consider. For instance, one expert, who had worked for more than 10 years in the music industry but also has deep technical expertise in blockchain, commented:

> All three [design principles] work cohesively to create value for a holistic solution. However, I see an issue in the current anti-money-laundering legislation. Musicians in most European countries would be unable to get a payout because of that legislation. So, in that sense, I have a hard time seeing the applicability of the principles in the current world situation. That said, the principles could direct the design of a solution – once the political structures are ready for blockchain. [Respondent 2]

In other words, the actability and effectiveness of the design principles depend not only on the technical design, but particularly on aspects related to governance and legislation. Notably, a recent European Commission working paper points out that regulatory uncertainty poses a significant barrier to the development of blockchain-based systems (EuropeanCommission, 2020). This is, in part, why we use design principles to evaluate our forward-looking, human-centered design, as a backward-looking, technology-centered evaluation would not be feasible at the time of writing (and for the foreseeable future, without design knowledge providing direction). As with many other areas involving blockchain (Bakos et al., 2021; Beck et al., 2018), new legislation and political progress are necessary to establish a regulatory foundation for decentralized DRM systems (Gebert, 2020). Additionally, respondents also confirmed the importance of aligning the interests of various stakeholders for decentralized DRM to be feasible:

> The broad strokes are there. The devil is very much in the details. There are many different platforms, organizations, distributors, agendas, and vested interests to align in order to have everyone adopt a centralized blockchain system like this. [Respondent 10]

Finally, the experts provided useful suggestions to improve the design principles. They commented that DP2 should explicitly identify *who* ensures consistency and completeness. Accordingly, we revised this design principle to specify explicitly that labels and publishers should ensure consistency and completeness. Other respondents made us aware of their concerns about receiving royalties in volatile cryptocurrency, leading us to suggest an existing stablecoin instead of a new cryptocurrency.

Demonstration

Having described in detail the design requirements and design principles for a decentralized DRM system for the music industry, we now suggest how such a system could be practically implemented, and what the benefits of such an implementation would be. Figure 3 illustrates a conceptual system architecture for a decentralized DRM system in the music industry. The system architecture can serve as a high-level context model for assessing and denoting the more detailed parts of an IT system. Compared to existing centralized designs, our decentralized design may contribute to increased transparency, efficiency, and consistency

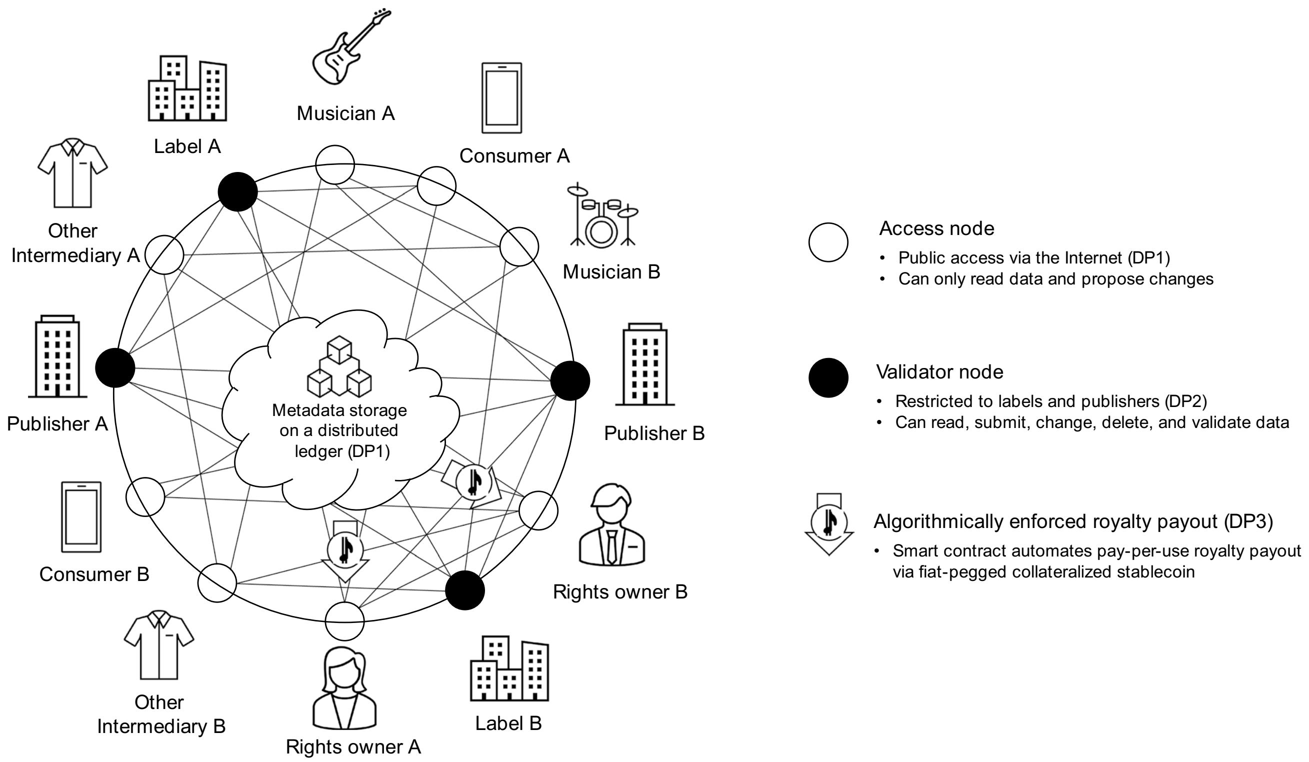

Fig. 3 Decentralized architecture for a DRM system in the music industry

by providing a global rights database shared on a distributed ledger, with more consistent and complete rights metadata and algorithmically enforced royalty payout to rights owners via stablecoin. Such a decentralized DRM system could also be more inclusive for rights owners, composers, creators, and consumers, as it allows greater participation in the storage and validation of metadata and royalty payout—especially if the software is open source (Beck et al., 2018).

From the viewpoint of major labels and publishers, who have so far been reluctant to participate in a global rights database due to lack of mutual trust hindering collaboration (Creative Edwards, 2016; Hardy, 2014; Industries, 2014), such a decentralized DRM system could also be preferrable over centralized ones. Because the royalty payout process would be algorithmically enforced through transparent rules embedded in mutually agreed upon smart contracts, the various participating stakeholders would no longer have to trust each other to play by the rules, thus potentially alleviating their trust issues and facilitating collaboration (Lumineau et al., 2021). Moreover, because metadata validation would be restricted by labels and publishers, these organizations could ensure consistency and maintain their current status and influence in the industry. We assume that such a system would ultimately benefit everyone involved, as it would increase surplus value that is currently being destroyed due to the present complexity, intransparency, and inefficiency of music rights metadata and royalty payout processes. Of course, much further work is needed to get there. Future studies should engage deeply with major labels and publishers as well as representatives of various rights owners, to explore how their interests can be optimally aligned in a decentralized DRM system.

As shown in Fig. 4, our design principles can work together distinctly and comprehensively to satisfy the design requirements for a decentralized DRM system. These design principles can be practically implemented with four corresponding design features, as shown on the right of Fig. 4, and elaborated in the ensuing paragraphs. We were inspired by Meth et al.'s (2015) distinction between design requirements, which should be satisfied by design principles, which in turn can be implemented with design features.

To satisfy DR1 (transparent music licensing structures), we suggest a public blockchain where everyone can read data (DP1), as this would maximize transparency—provided that labels and publishers support such a solution. Failing that, a private blockchain on the premises of these organizations might still improve transparency between them, which would be an improvement compared to the current situation. However, a private blockchain would strongly limit the economic benefits that could be gained from transparent music

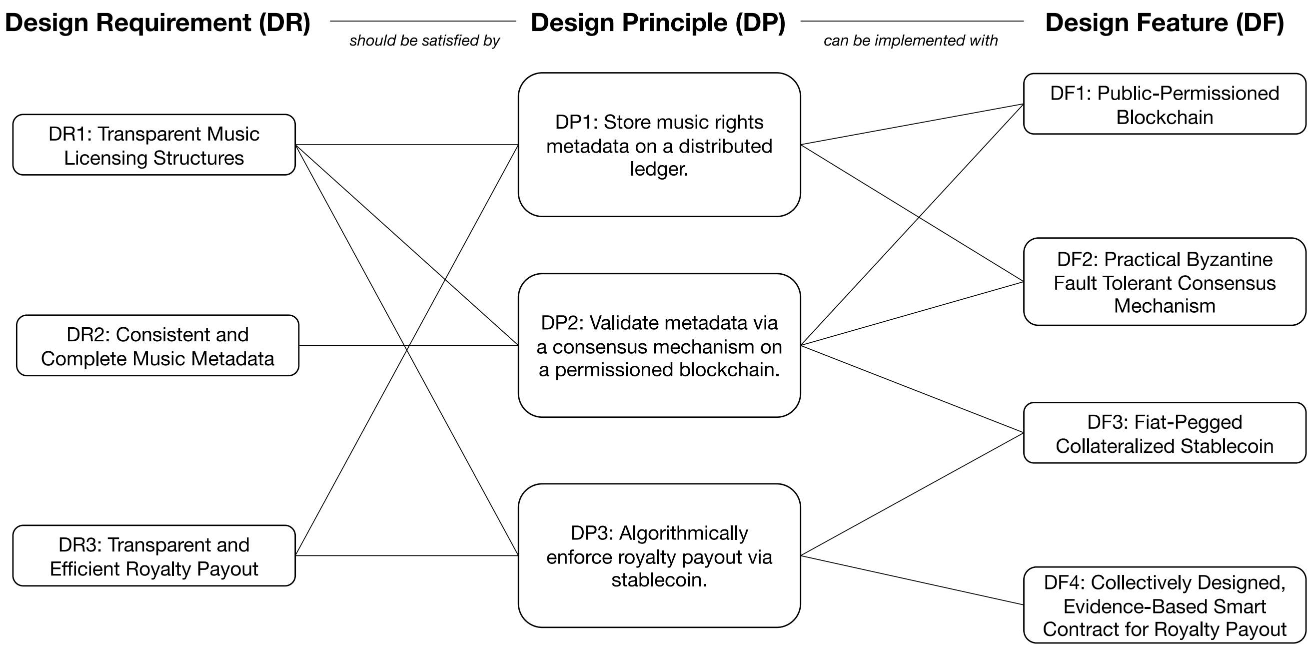

Fig. 4 Mapping design requirements to design principles and design features

licensing structures. It may also lead to various local consortia instead of one global one, which would offer very little improvement to the current situation in the music industry (Creative Hardy, 2014; Industries, 2014; Kwok et al., 2003; Zhang, 2018). Hence, we suggest:

DF1: A decentralized DRM system can be implemented with a public-permissioned blockchain

To address DR2 (consistent and complete metadata), we suggest a permissioned setup (DP2), where labels and publishers validate data in combination with a unique identifier for rights owners, which, in combination, would improve consistency and completeness. This would be superior to a permissionless blockchain and likely more desirable as well, because a permissioned blockchain offers a more predictable outcome, which is beneficial for security and keeps established organizations in control, and therefore may be a better fit for industry applications (Bakos et al., 2021; Beck et al., 2018; Zavolokina et al., 2020). DP2 would also improve the transparency of licensing structures (DR1), because the various stakeholders would be brought together to validate data on a shared and publicly accessible blockchain, rather than operating their own proprietary and protected databases. The choice of a permissioned blockchain implies that the practical byzantine fault tolerance algorithm is an appropriate and sensible consensus mechanism, because it affords greater efficiency and speed than proof-of-stake or proof-of-work consensus mechanisms (Bano et al., 2019; Castro & Liskov, 1999). Hence, we suggest:

DF2: A decentralized DRM system can validate metadata with a practical byzantine fault tolerant consensus mechanism

To address DR3 (automated and efficient royalty payouts), we suggest a smart contract that algorithmically enforces royalties to be paid out as a stablecoin (DP3) to minimize volatility. While combining a smart contract with a stablecoin would be the most transparent and efficient option to automate royalty payout, smart contracts and stablecoins are still not widely adopted at the time of writing. Due to such widespread concerns regarding the relatively recent stablecoin technology, we suggest that a fiat-pegged collateralized stablecoin is preferable over a non-collateralized stablecoin, because collateralized pegging has empirically been more stable and crisis-resilient than its non-collateralized counterpart (Eichengreen, 2019; EuropeanCommission, 2020; Lyons & Viswanath-Natraj, 2020). Moreover, we suggest that the stablecoin should be pegged to a fiat currency that is widely regarded as relatively stable, such as the US dollar or Swiss franc, rather than pegging it to more volatile currencies. Alternatively, if rights owners are unwilling to accept receiving their royalties as stablecoins, the blockchain could still serve as a record of royalty balances, while the payout would need to be approved by an authorized member of the consortium that runs the blockchain. In such a case, an intermediary would still be necessary, but the intermediary could use the royalty balance data from the blockchain to pay out royalties more efficiently, which is an improvement to the current situation (Domingo, 2018; Kwok et al., 2003; Molinder, 2018; RIAA, 2022; Zhang, 2018). In short, we suggest:

DF3: A decentralized DRM system can pay out royalties with a fiat-pegged collateralized stablecoin

Finally, the development of the smart contract itself will be an enormously challenging and complex endeavor worthy of its own research program. Although smart contracts could potentially increase the transparency and efficiency of royalty payout for music rights, an effective smart contract design requires careful consideration of social, technical, economic, legal, and political aspects (Bodó et al., 2018; Gebert, 2020). Because there is currently no international consensus on the scope, duration, and enforceability of IP rights, every individual music right—of which there are many different types—could legally be enforced differently (or not) in every single jurisdiction. This could lead to potentially prohibitive transaction costs due to the massive amount of coordination involved in on-chain and off-chain transactions (Bodó et al., 2018). Nonetheless, a blockchain-based smart contract could at least in part contribute to resolving this conundrum by creating transparency where it is sorely needed—namely, by allowing rights owners to access information about metadata and payment flows. This alone could alleviate concerns about a system that is currently perceived as unfair and unequal (Beard et al., 2017; Domingo, 2018; Edwards, 2016; Hardy, 2014), even if it would not change the money flow (Bodó et al., 2018). While our study may help to understand how and why the current payout process is flawed, improving it will require a major collective effort involving many stakeholders from the music industry, in collaboration and consultation with academic research and scientific evidence. In short, we suggest:

DF4: A decentralized DRM system can pay out royalties with a collectively designed, evidence-based smart contract

Discussion

We contribute to the IS literature in various ways. First, we suggest three design requirements of DRM systems. This contributes a generalized problem understanding (so-called Omega knowledge about the domain, as suggested by Vom Brocke et al., 2020), which extends the literature on DRM systems with empirical descriptions of the main practical obstacles and current challenges in the music industry, as well as appropriate ways to address them with DRM systems. Second, we offer prescriptive solution design knowledge (so-called Lambda knowledge about the potential solution space, as suggested by Vom Brocke et al., 2020) in the form of design principles for decentralized DRM systems. This contributes to the design knowledge base by informing the development of blockchain-based solutions for future DSR projects. For instance, blockchain developers could use our design requirements, design principles, and design features for further development into detailed DRM system architectures and prototypes. Since the persistent issues with centralized DRM systems results in a pressing need for both domain knowledge as well as technical knowledge, our study may also inform practitioners who wish to apply or extend our design principles in other contexts. For instance, regulators, designers, and industry professionals can build on this contribution to develop decentralized DRM systems for other media industries.

Inspired by Hevner and Gregor's (2020) idea to envision digital innovations via a DSR lens, we used our design principles to envision the potentials of decentralized DRM systems. By ensuring close links across problem and solution spaces (Vom Brocke et al., 2020), as well as by means of a design principle evaluation (Iivari et al., 2020), we established confidence in the design principles. Although evaluation has always been an important part of the design cycle (Hevner et al., 2004; Prat et al., 2015; Venable et al., 2016), design principle evaluation is a nascent part of the DSR methodology (Iivari et al., 2020). Early examples include Lee et al.'s (2018) design principles for "Bright Internet," where the authors evaluated design principles as a proof of concept, as an instantiation of an artifact, and deployment into such a vast domain as the general Internet was not feasible. Similarly, a large-scale instantiation of a DRM system in the music industry would not be feasible within the usual scope of a single research project. Accordingly, our evaluated design principles serve as a proof of concept, contributing a foundation to guide subsequent studies who wish to develop decentralized DRM systems for the music industry.

The design principles contribute applicable, prescriptive guidance derived from extant literature and empirical data. The design principles are applicable for DSR researchers, blockchain developers, and music industry experts by summarizing insights that are specific to DRM systems, and that promise to be useful but are not yet widely applied. The principles are presented in generalized form rather than as "cookie cutters," meaning that their application requires creativity, imagination, and adaptation to situated contexts. In doing so, people should not simply cherry-pick some principles while ignoring others; instead, they should consider the interdependent principles together. Our hope is that our contribution will guide further research in close collaboration with major labels and publishers to examine how our proposed design principles can be optimally implemented.

Our contribution should help the music industry to move one step closer toward an integrated solution that resolves the decades-old DRM challenge. Whereas existing centralized DRM systems emphasize digital watermarking and IP protection by restricting usage of information goods (Kwok et al., 2003; Vernik et al., 2011; Zhang, 2018), thereby benefitting primarily major labels and publishers but lowering the overall benefit for rights owners, musicians, and consumers, our contribution proposes a feasible design for an integrated blockchain-based DRM system. Contrary to previous recent attempts to decentralize DRM systems (Halgamuge & Guruge, 2022; Kapsoulis et al., 2020; Kim & Kim, 2020; Li et al., 2021; Zhao & O'Mahony, 2018), our design does not focus on DRM-enabled usage restriction, which has been shown to be counterproductive (Zhang, 2018). Instead, we argue that a decentralized DRM system should enable pay-per-use through public metadata storage (DP1), permissioned metadata validation (DP2), and algorithmically enforced royalty payout (DP3). This integrated and flexible architecture should help to design a blockchain-based DRM system that allows to align smart contracts with jurisdictional privileges of state authorities while also providing economically viable mechanisms to maintain consistent metadata and royalty flows to ensure necessary network effects.

As with every study, ours has some limitations. We acknowledge that our design principles are high level principles. If mapped to a design knowledge solution space, the principles would be rated highly on the projectability scale as our combination with problem domain and solution technology spans many application domains; as result, their prescriptive power is limited (Vom Brocke et al., 2020). Nonetheless, our formative-conceptual evaluation established a high level of confidence in the design principles, meaning that they can serve as a guiding foundation for further design research to amplify or contextualize the abstract design knowledge into more specific instantiations (Vom Brocke et al., 2020). We also acknowledge that our reliance on a moderately sized qualitative data set from experts in the music industry and blockchain technology limits the generalizability of our insights. However, our use of the appreciative interviewing technique contributes high internal validity of the experts' perceptions of the key business problems and potential solutions (Schultze & Avital, 2011). We further increased the validity and credibility of the findings by connecting them to the existing knowledge base (Hevner, 2007) on DRM systems.

In conclusion then, our study advances a generalized problem understanding and prescriptive solution design knowledge for decentralized DRM systems. Such systems require transparent music licensing structures, consistent and complete music metadata across organizations, and efficient and transparent royalty payouts. To meet these requirements, a decentralized DRM system should (1) store music rights metadata on a distributed ledger using a public blockchain to make licensing structures transparently visible to everyone, so that rights owners can claim royalties; (2) validate music metadata with a consensus mechanism on a permissioned blockchain and assign a unique identifier to rights owners, so that labels and publishers can ensure consistency and completeness; and (3) algorithmically enforce royalty payouts with a smart contract to make payout processes more transparent and efficient, so that rights owners can receive royalties automatically in the form of stablecoin.

Existing centralized DRM systems mostly serve the interests of major labels and publishers, which comes not only at the detriment of IP rights owners and consumers, but is also counterproductive for labels, publishers, and other major stakeholders themselves. Compared to such suboptimal centralized design, our proposed decentralized DRM system architecture promises to increase transparency, consistency, and efficiency. Unlike other recently proposed blockchain-based DRM systems, which mirror the usage functionality of existing centralized systems, our design focuses on enabling automated per-use royalty payout to rights owners via a more comprehensive and complete global rights database that is shared on a distributed ledger. We argue that such a solution would ultimately benefit the entire music industry by increasing surplus value that is currently being destroyed through suboptimal designs. We hope that our study inspires and guides future studies on decentralizing DRM systems in various media industries.

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