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WATERMARKING TECHNOLOGY and Blockchains in the Music Industry

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BLOCKCHAIN TECHNOLOGY IS BEING PROPOSED AS A TOOL FOR SOLVING MUSIC INDUSTRY PROBLEMS RELATED TO LICENSING AND ROYALTY TRACKING. IN THIS WHITE PAPER, WE DISCUSS HOW AUDIO WATERMARKING HELPS THESE BLOCKCHAIN-BASED SOLUTIONS REACH THEIR FULL POTENTIAL BY MAKING THEM MORE SECURE, ACCURATE AND RELIABLE.

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SCAN IMAGE

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Introduction and Executive Summary

The digital age has caused a massive expansion in the ways that people consume music, including many different types of digital music services. It is no longer feasible to license music and compensate rights holders – such as composers, recording artists, music publishers, and record labels – using the paper-derived processes that are still prevalent in the music industry. Rights and royalty management processes have struggled to keep pace with developments in music access models and the scale of consumption worldwide.

The most fundamental problem has been the lack of authoritative, accessible sources of data about music copyright information, including owners of rights and license terms. Validated information is critical for music service providers and rights administrators to process royalty transactions for the billions of music uses that occur each year. The lack of easily accessible, complete, and correct information causes inefficiencies, ambiguities, inaccuracies, and legal risks. The results have included pools of unclaimed royalties, erroneous transactions, and lawsuits.

The past few years have seen a number of attempts to solve these problems by building single large comprehensive databases, such as the Global Repertory Database (GRD), the World Intellectual Property Organization's International Music Registry (IMR), and the International Music Joint Venture (IMJV) among royalty collecting societies from the US, UK, Canada, and the Netherlands. None of these efforts have succeeded, due to issues of funding, control, and the sheer complexity of gathering and maintaining all that data in one place; so the problems remain.[1]

Blockchain technology has arisen as a way to bring secure, reliable, and scalable distributed transaction processing to music licensing. Significant investment and technical talent have entered the music industry through blockchain technology. Blockchain technology replaces monolithic central systems with an approach based on interoperability among existing databases and distributed transactions.

However, blockchains are not without practical limitations, as we will discuss below. One important limitation is that digital music files themselves will continue to exist outside of blockchains. This raises a core concern: how is it possible to ensure that the blockchain data stays linked to the relevant audio? This gives rise to the need to link music files to blockchain-based transactions involving them. The most secure and reliable way to associate identifiers with digital music files is with watermarks. As we will show in this white paper, blockchain applications for music are deficient without digital watermarking.

In this white paper, we'll discuss the ways in which audio watermarks help solve problems plaguing music licensing and royalty tracking and enhance many proposed solutions that involve blockchain technology.

The white paper will begin with some background information about copyrights in the music industry and identifiers for copyrighted works. We follow with a description of the methods for associating unique identifiers with digital music files, and we show why digital watermarks are superior to other methods. Finally, we will discuss blockchain providers and some of the most promising blockchain applications for the music industry, and we describe how watermarking creates more secure and reliable solutions.

Music Copyrights and Identifiers

In this section, we'll provide some basic information on copyrights in the music industry and some of the entities that manage them.2 Then we will describe the types of identifiers and metadata that exist as standards and/or are necessary to identify digital music for purposes of rights and royalty management and transaction processing.

BACKGROUND ON MUSIC RIGHTS AND ROYALTIES

For every piece of recorded music, there are two copyrights associated with it: one for the composition ("musical work"), the other for the recording itself ("sound recording"). A recording of a composition is said in copyright law to "embody" the composition.

For every piece of recorded music, there are two copyrights: one for the composition, one for the recording itself.

The copyright on the composition is assigned to one or more composers, each of whom is represented by one or more music publishers. For example, the Lady Gaga song "Paparazzi" has two composers (Stefani Germanotta, a/k/a Lady Gaga, and Robert Fusari) and two publishers (House of Gaga Publishing and Sony/ATV). If multiple composers or multiple publishers are involved, they share royalties according to agreed percentage splits.

The copyright in a sound recording, on the other hand, is owned by a recording artist or record label.[3] The U.S. release of Lady Gaga's recording of "Paparazzi" is on Interscope Records, a label within Universal Music Group.

Rights on Musical Compositions

Copyright law grants content creators a "bundle" of several exclusive rights. Musical compositions and sound recordings each have their own bundles. For musical compositions, the rights that are most relevant to this discussion are the rights to copy (reproduce), distribute, and perform them in public. "Performance" in this case means on a recording as well as before a live audience. The rights to copy and distribute are combined by music industry convention into one set of rights called "mechanical" rights. So, the primary rights that composers can license to digital music services are performance and mechanical rights.

Other rights on musical compositions are relevant for licensing purposes even though they are not explicitly part of the "bundle" defined in copyright law. A prominent example is synchronization (sync) rights, which are usually necessary when a composition is used within another media experience, such as a TV show, movie, video ad, game, website, or other visual media. For example, if an ad agency wanted to produce a TV commercial for a Nikon camera and use "Paparazzi" in the background, it would have to license sync rights from House of Gaga Publishing and Sony/ATV.

Major music publishers can administer all of these rights. In addition, organizations called collecting societies, or collective rights management organizations, often administer these rights on behalf of publishers, for reasons of efficiency or collective bargaining power. Different types of collecting societies manage different rights:

- **Performing rights organizations (PROs)** handle performance royalties. In the United States, these are ASCAP, BMI, SESAC, and Global Music Rights (GMR). Each music publisher and each composer belongs to one of these.[4]
- **Mechanical rights organizations (MROs)** handle mechanical royalties. Major music publishers administer their own mechanical rights; organizations such as the Harry Fox Agency (HFA, owned by SESAC) manage mechanical rights for smaller publishers.

Below we will see how publishers and these collecting societies handle royalties from music service providers.

Rights on Sound Recordings

Recording artists also have exclusive rights to copy, distribute, and perform[5] their recordings, but the licensing and royalty schemes for recording artists are different from those for composers. In addition to copying, distribution, and performance, other rights are licensed for digital sound recordings, many of which are specific to types of digital music services, such as paid permanent download, conditional (e.g., time-bounded or device-tethered) download, paid subscription stream, or ad-supported stream. These rights are specified in license agreements with digital music service providers, or DSPs.

When an artist records compositions, a record label typically owns the copyrights to the sound recordings.[6] The label manages licenses for reproduction and distribution of the sound recordings, as well as the logistics of distributing them to DSPs and manufacturing physical products such as CDs and LPs.

The most important rights for music licensing and royalty purposes are mechanical and performance rights.

Labels also manage licenses for other purposes, such as remixes and the use of recordings along with video (analogous to sync licenses for compositions). So, if the ad agency in the above example wanted to use “Paparazzi” in the Nikon camera commercial, it would also have to obtain a license for the sound recording from Interscope. However, if the ad agency wanted to hire another artist to cover the song for the commercial, it need only get licenses from the publishers, because it isn’t using Lady Gaga’s sound recording.

DSPs pay royalties to record labels for reproduction and distribution of sound recordings. The simplest scenario is a music download service such as Apple iTunes: when a user purchases a music track or album from iTunes, Apple pays the label a royalty for that reproduction and distribution.

Things get more complicated with streaming music services, which provide what the law defines as "digital performances" of music. In the United States, the law recognizes two basic types of streaming services: interactive and noninteractive. Interactive streaming services are those that let users choose the specific music they want to hear; examples include Spotify, Apple Music, and TIDAL. Noninteractive services are those in which the service provider programs the music, such as Pandora[7], iHeartRadio, Sirius XM satellite radio, and Music Choice for cable TV.[8]

Both types of streaming services pay digital performance royalties on sound recordings. Interactive streaming services pay royalties directly to record labels, while noninteractive streaming services usually pay them to a single Sound Recording PRO called SoundExchange, which distributes them to labels.

Content and Royalty Flows

The following figures show some of the most important of the many different content and money flows in digital music.[9] The following are explanations of "typical" flows, after which we describe the most important variations.

Figure 1 depicts the flows for musical compositions, involving songwriters and publishers, from most types of DSPs (with differing royalty amounts for different service types). In this process, a DSP has a catalog of recordings available, each of which embodies a composition.[10] When the DSP delivers a recording to a user (whether by download or stream), the DSP pays a mechanical royalty to an MRO and a performance royalty to a PRO on the underlying composition; both of these pass along shares of those royalties to the publisher. The publisher pays the songwriter(s) shares of each of the two royalties.

Figure 2 shows the flows for sound recordings, involving recording artists and labels, from digital music download services such as iTunes and Amazon. In this case, the music service pays a royalty to a record label for each track that a user downloads. The label passes mechanical royalties to the publishers of the underlying composition (as above) and pays a percentage of the remainder to the recording artist.

Figure 3 shows the flows for sound recordings from interactive streaming DSPs such as Apple Music, Spotify, and TIDAL. The flow is similar to the download scenario in Figure 2, except that the interactive stream counts as a performance of the underlying composition (as well as a digital performance of the sound recording), so the DSP must pay a performance royalty to the relevant PRO as well as to the record label.

Figure 4 shows the flows for noninteractive music services, which pay sound recording performance royalties to SoundExchange (the Sound Recording PRO) as described above.[11]

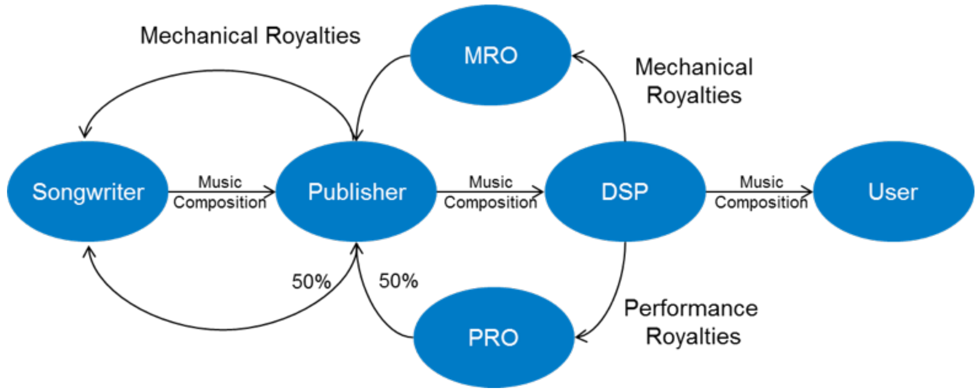

Figure 1 above: Typical musical composition royalty flows from digital music service providers.

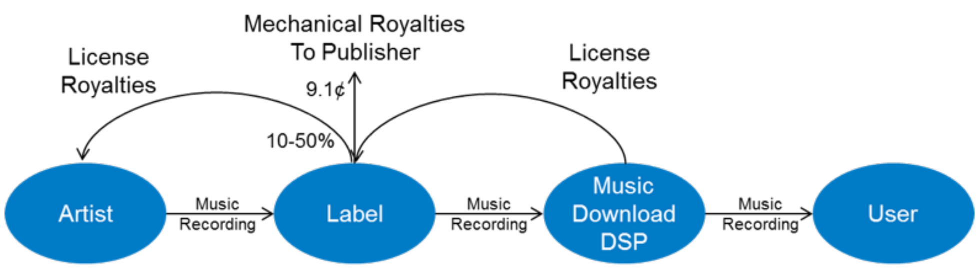

Figure 2 above: Typical sound recording royalty flows from digital music download services.

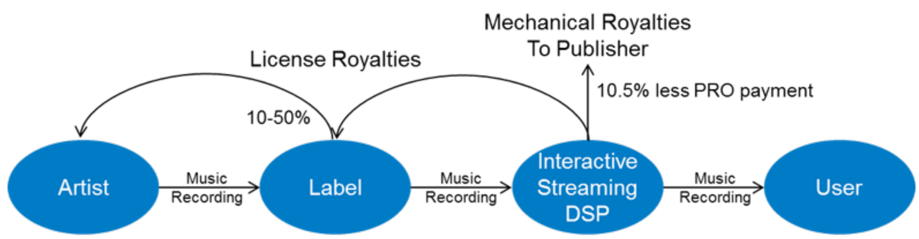

Figure 3 above: Typical sound recording royalty flows from interactive streaming services.

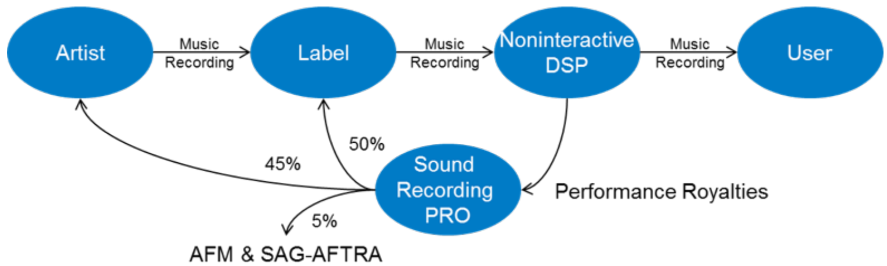

Figure 4 above: Typical sound recording royalty flows from noninteractive (radio-like) streaming services.

These flows become different in certain scenarios. In some cases, DSPs deal directly with music rights holders and bypass collecting societies:

- **Figure 1:** Major publishers (such as Sony/ATV, Universal Music Publishing, and Warner/Chappell) do not use MROs to process mechanical royalties; instead DSPs pay those publishers directly.
- **Figure 1:** Certain DSPs sometimes do “direct deals” on performance royalties with major publishers that bypass PROs. For example, Pandora has direct license agreements with several major music publishers.
- **Figure 4:** Similarly, noninteractive streaming DSPs sometimes do direct deals with record labels and pay digital performance royalties directly to them instead of SoundExchange. For example, Pandora has direct deals with all three major record label groups (Sony Music Entertainment, Universal Music Group, and Warner Music Group), and Sirius XM has direct deals with some independent labels.

Conversely, the proliferation of DSPs has given rise to new types of services that interface with DSPs on behalf of independent labels or artists:

- **Figures 2-4:** Independent labels often work through aggregators such as The Orchard, INgrooves, and FUGA, which submit recordings to DSPs and process rights and royalties from them on the indie labels’ behalf.
- **Figures 2-4:** Independent recording artists often use digital distributors such as CD Baby, TuneCore, and DistroKid, which aren’t record labels but function like them for these purposes.

This should give some idea of the number of transactions that must occur whenever a DSP plays or downloads a music track for a user. Each play or download involves two distinct sets of rights holders and rights, and various administrators that process licenses and royalties on those rights.

MUSIC IDENTIFIERS

As shown above, the licensing flows in the industry require the ability to track rights and royalties for sound recordings as well as for the compositions that they embody. At a minimum, this requires two things: unique identifiers for sound recordings and linkages between those sound recordings and the compositions they embody.

Standard Identifiers

A standard unique identifier for sound recordings exists and is widely used among record labels: the ISRC (International Standard Recording Code).[12] Compositions also have unique identifiers – ISWCs (International Standard (Musical) Work Codes)[13] – but they are not universally used, at least in the United States.

A few other identifiers in music are also important. IPI (Interested Party Information) is widely used among PROs to identify holders of rights in musical compositions. A newer standard, ISNI (International Standard Name Identifier)[14], identifies creators, which can also include musicians. The increasing use of ISNI by singer-songwriters indicates that ISNI is “crossing over” from the recording to songwriting domains, whereas the converse is not true for IPI. Finally, the UPC standards for retail products are widely used for albums and other recorded music products.

Linking Recordings to Compositions

Unfortunately, there is no single, authoritative source for mapping recordings to their underlying compositions.[15] This is the source of many problems with rights and royalty management in music today.

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The combination of song title and songwriter(s) is usually sufficient to identify compositions unambiguously.[16] In many (though not all) cases, record labels will provide information to DSPs that is sufficient to identify composition rights holders, such as the names of composers, publishers, and PROs involved.

However, there are also many cases in which digital music files are “found” (e.g., in personal collections) rather than supplied through feeds from labels, aggregators or distributors to DSPs. Among the most common scenarios for “found” music are a DJ using music for a remix or mashup, and a producer selecting music to use in an ad, TV show, movie, online video, or VR experience – such as in the Nikon camera ad discussed above (see p. 4). The latter case involves sync rights, which are a fast-growing segment that accounted for 20% of music publishing revenue in 2014, or almost as much as mechanical licensing revenue.[17]

For such “found” music files, there is no guaranteed, authoritative place to find the publisher for the underlying composition. There are a few proprietary databases for matching recordings to compositions, such as those maintained by HFA and Music Reports Inc. (MRI), but these databases are not comprehensive.

> Digital music files from personal collections are often used for remixes, mashups, advertisements, or videos. For such files, there is no guaranteed, authoritative place to look up ownership or rights information.

Nevertheless, associating an ISRC with a digital music file helps in getting basic information. An ISRC database[18] can usually be queried to get song title, artist and release year information. It can also tell which compilations (albums) the track is included in. This information can then be used to look up the composition in a third party database or that of a PRO, though there is no guarantee of a match without information about the composer(s).

Therefore, the best and most efficient metadata to associate with a digital music file for rights and royalties tracking purposes is an ISRC plus composer name(s) and PRO(s). If the ISRC is known, then the song title can be retrieved from the ISRC database, and if the song title and composer is known, then the composition can be identified through the PRO(s). Each PRO can provide some further information, such as publishers and some information about ownership shares within that PRO.[19]

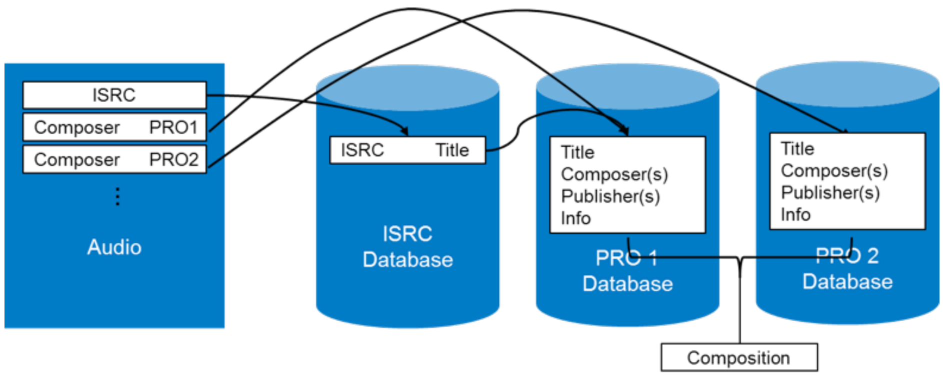

Figure 5 above: Using an ISRC together with composer and PRO names to identify a musical composition.

Figure 5 depicts a hypothetical way to achieve the desired metadata association by linking existing databases. It shows a digital audio file with an ISRC and a list of composers with their PROs (two in this case). An ISRC identifies the recording uniquely. Using it to query the ISRC database yields a composition title, though that doesn't identify the composition uniquely. The composition title can be used together with composer names to query the databases of the PROs for each composer, each of which will yield information about the composition. For each of the two composers, it's possible to get the publisher(s) and other information from the database of that composer's PRO, including information on the percentage ownership shares (known as "splits") of each entity.[20] The result should be full information about the composition and its ownership.

This technique is not exact. For example, it would require some "fuzzy search" methods: song titles in the ISRC database will include variations (such as "… (Remix)" or "… (feat. Guest Artist)"), and composer names will vary (such as "Jagger, Mick," "Jagger, Mike," and "Jagger, Michael Philip").[21] And of course it does not account for data entry errors.

In sum, standard identifiers for and databases of music recordings, compositions, and rights holders exist, but they are neither ubiquitous nor comprehensive enough to enable automated identification of music without errors, gaps, or ambiguities. As we'll see, mechanisms are available to use existing identifiers and databases to compile reasonably complete sets of information about music, but they are far from foolproof; the principle of "garbage in, garbage out" applies as much in music as it does anywhere.

Binding Identifiers to Digital Music

We described above the sets of metadata that are desirable for identifying music and linking recordings with compositions. Now we consider how to associate a set of metadata with the music it identifies. Given the failure of efforts to create a single authoritative database of music rights and ownership (see p. 3), the idea is to ensure that distributed data sources can be consulted in real time to find rights and ownership information.

Ideally, metadata should "travel" with each music file as it makes its way from an artist or record label to a DSP or from a DSP to an end user.

Ideally, the metadata should "travel" with each digital music file as it makes its way from an artist or record label to a DSP, from a DSP to an end user, or as the file is "found" as described above.

Four fundamental methods are commonly used to associate identifiers with digital music files: header metadata, hashes, acoustic fingerprints, and watermarks. These are shown in Figure 6.

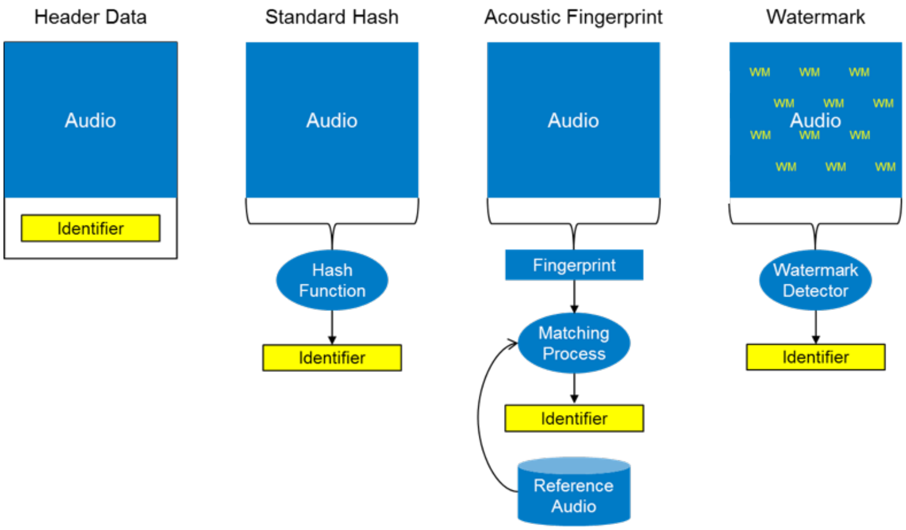

Figure 6 above: Methods of associating identifiers with digital music files.

Each of these methods can be judged on the following key criteria:

- **Robustness:** the identifier remains associated with the file even after the file has been transformed in various ways, such as transcoding, downsampling, excerpting, pitch-shifting, re-equalizing, and digital-analog-digital conversion.
- **Data Flexibility:** the same audio data can exist in multiple files with different identifiers.

- **Identifier Reliability:** the identifier can reliably identify the recording in the file for rights and royalty management purposes.
- **Security:** the identifier is difficult to remove or change without altering or marring the content.

Criterion	Header Metadata	Hashes	Acoustic Fingerprints	Digital Watermarks
Robustness			✔	✔
Data Flexibility	✔			✔
Identifier Reliability	✔	✔		✔
Security			✔	✔

Table 1 above: Comparison of methods of binding identifiers to music recordings.

Table 1 summarizes the pros and cons of the four methods with respect to each of these criteria. Here are descriptions of each of these methods along with their pros and cons:

There are four fundamental ways to associate identifiers with music files: header metadata, hashes, acoustic fingerprints, and digital watermarks.

Header Data

Most digital music file formats have places for metadata, which can include identifiers. A prominent example is ID3 tags that can be included with MP3 files.[22] These are very simple to insert into audio files. They can contain just about any values, and it's possible to assign multiple identifiers to different files containing the same recording.

The biggest disadvantage of header data is that it is trivially easy to change or remove without affecting the content, whether intentionally or not. For example, anytime a song is played over speakers and re-digitized, the metadata does not appear in the resulting file. Even in a purely digital environment, header metadata also tends not to survive when a copy of the file is made that is then changed in certain ways, such as transcoding or stream recording.

In other words, header data is neither robust nor secure. To make it robust and secure, it's possible to encrypt the entire file and only allow access to the data (including the header data) for particular purposes and with proper credentials, like a digital rights management (DRM) scheme. We discuss a variation on this theme below (see p. 17). This has been attempted,[23] but it is very impractical, for reasons discussed below. Encryption would also strongly discourage licensing of music in various situations, such as the "found" music scenarios discussed on p. 9 above.

Hashes

One way to establish a unique identifier for a digital music file is to run a type of algorithm called a hash function on the data in the file. A hash function is similar to a "funnel" for data: it takes arbitrarily large input and produces a small, fixed-size output, called a hash or hash value. Hash functions have the following properties:

- When a hash function is run on identical sets of input data, it produces identical hash values.
- Different sets of input data are extremely likely to produce different hash values, even if the differences are tiny.
- Conversely, if two hash values are the same, then it is extremely likely that the input data sets that produced them are identical. In other words, it is extremely unlikely (though not impossible) that two different input data set will produce the same hash value (this is called a "collision").

There are several widely used hash functions, and there is not a single standard used in music metadata, though SHA-1 and MD5 are the most common.

The advantages of hash functions are that they are derived directly from the content, not separate from it as header data is. Therefore hashes provide a very high degree of reliability about the content's identity – as long as the file is not altered in any way.

There are two big disadvantages with standard hash functions. One is that they do not give the copyright owner or distributor any flexibility or control over identifiers. The other is that, by design, they are not at all robust: anyone can change the hash value by changing as little as a single bit of the audio data, and different versions of the same content (e.g., in different formats, codecs, or bitrates) will have different identifiers, which may not be the intended result. For example, record labels often submit music tracks to a DSP along with hash values; but then the DSP typically transcodes the files to the codec(s) and bitrate(s) that it provides to users, rendering the label-supplied hash values meaningless.

Acoustic Fingerprints

An acoustic fingerprint is a special type of hash function that returns the same value for all inputs that sound the same to a human listener.[24] Instead of merely running an algorithm on input data, an acoustic fingerprinting algorithm computes a set of descriptors of the sound (the fingerprint) and compares that set to a database of reference fingerprints. To do this, the fingerprinting service has to ingest reference audio files from record labels (or other entities, such as indie artist distributors), compute fingerprints on them, and enter those reference fingerprints into its database. It does this on a continuous basis as labels feed it new releases. Then, when a music file is submitted to a fingerprinting service, the service performs a matching process which often returns a list of candidate matches that exceed a certain probability threshold.

As with standard hashes, fingerprints are inherent in the data, so they can't be removed or separated from it. But unlike standard hashes, it's difficult (if not impossible) to alter a file's fingerprint without perceptibly marring its sound to a listener. This makes fingerprinting a robust and secure method of associating identifiers with music files.

Fingerprinting solutions have been available from vendors such as Audible Magic, Gracenote, TuneSat, and BMAT that have been compiling reference fingerprints of recordings for years. They have improved to the point that they are very good at identifying music tracks, as long as the label or distributor has submitted the music to the fingerprinting vendor in advance. However, fingerprinting is not very good at differentiating between certain versions of a given music track that might need to be distinguished for rights and royalty management purposes, such as an original recording versus a digital remastering of it.

The other limitation with fingerprints is that it is impossible to assign different identifiers to different files containing the same recording; i.e., fingerprinting lacks data flexibility.

Watermarks

A digital audio watermark is a set of data embedded directly into audio in such a way as to be imperceptible to listeners. Watermarks are the only means of associating metadata with digital music files that meet all of the criteria in **Table 1** above.

Watermarking schemes have also been available for several years from a few different vendors. A watermarking implementation consists of tools for embedding an identifier or metadata into a file and for detecting watermarks and extracting the identifier or metadata – called the payload – from them. A well-designed watermarking scheme is robust to transformations such as transcoding, excerpting, digital-analog-digital conversion, and many types of signal processing (pitch shifting, EQ, etc.). Watermarking can be used to associate any data desired, including different identifiers with different files containing the same recording (i.e., watermarking provides data flexibility). In addition, watermarks can allow a level of certainty comparable to header metadata.

The one disadvantage of watermarks is that they need to be inserted into legacy audio content. Yet because watermarks are most useful when they are tailored to distribution channels, they can be inserted at the point of distribution – just as header metadata can be. We will see examples of this below.

Watermarks combine the robustness and security of acoustic fingerprints with the identifier reliability of header metadata – the best of all worlds.

Recent advances in watermarking technology allow extensibility and flexibility in terms of the payload, and enable speedy detection of watermarks (requiring just a few seconds of the audio, even with ambient noise), while maintaining high robustness and inaudibility.

As with header metadata, an identifier embedded into a music file with a watermark has complete reliability, because it is whatever the embedder intended and can't be altered without seriously disrupting the audio itself. Thus, watermarks combine the robustness and security of fingerprints with the identifier reliability of header metadata – the best of all worlds.

Instead of embedding the entire set of metadata that can identify both a recording and a musical composition into a file as a watermark payload, a payload can be used as an identifier to reference the required metadata. For example, consider the case described on pp. 9-10 of associating a combination of ISRC, composer, and PRO with a sound recording. A record label can use the scheme described above to facilitate rights and royalty management via watermarking. It can obtain a unique payload identifier from the watermarking vendor, associate this payload identifier with this metadata, and embed the payload identifier as a watermark into the digital audio file using tools provided by the watermarking vendor.

This scheme makes it possible to include metadata in addition to that mentioned above. For example, it can be useful to include an indicator of a channel through which a music track is being made available, such as a type of DSP (e.g., paid download, paid subscription interactive stream, ad-supported interactive stream, or radio-style noninteractive stream) or individual DSP (e.g., iTunes, Google Play, Spotify). For example, the DDEX music industry message standard[25] has a <UseType> tag for the former, with values such as <PermanentDownload>, <OnDemandStream>, and <NonInteractiveStream>; these can be added to records stored in a watermark payload ID database.

In the video and e-book worlds, certain types of services embed so-called session-based or transactional watermarks in files, which contain identifiers of individual purchase transactions. This is not conventional practice in the music industry, but it could be possible to embed a transactional watermark that serves as an index to a DSP's transaction database.

Blockchains and Music

There's a lot of talk these days about the use of blockchain technology for music applications. What is a blockchain? A blockchain is a distributed ledger – a database of transactions, of which every party to every transaction has a complete copy at all times. Blockchains take advantage of cheap storage, reliable Internet connectivity, and state-of-the-art security to replace large, monolithic, proprietary systems with open, lightweight, distributed systems that are largely based on open-source software. Blockchains are designed to be highly reliable: transactions are written to blockchains atomically (i.e., either completely or not at all) and are essentially impossible to change once written.

The best-known example of blockchain technology – the application that put the technology on the map – is the virtual currency Bitcoin. Bitcoin has its own blockchain, but many others exist. In fact there can be arbitrarily many blockchains, and several have already been established for different types of applications.

Various types of blockchain-based applications have been proposed for music. Most of these applications use blockchains for various forms of "behind the scenes" or "B2B" rights and royalty processing, while others include end users in transactions. Here are some examples:

Ujo Music

Ujo Music (ujomusic.com) is a project of ConsenSys, a startup incubator focused on the Ethereum blockchain, which supports a technology called smart contracts. A smart contract is a protocol that ensures that participants in a blockchain adhere to machine-readable rules, such as – in this case – license terms for content. Ujo Music built a prototype for the innovative British singer/songwriter Imogen Heap. The system makes it possible to license Heap's song "Tiny Human" on different terms: as a permanent download, a stream, stems (individual tracks, for remixing), or for sync rights (see p. 4).

With the Ujo Music "Tiny Human" prototype, it's possible to purchase permanent download rights (as a consumer would do), but it's also possible to acquire the right to sell downloads of the song (as a DSP would do) and return a percentage of the purchase price to the copyright holder.

Core Rights

Core Rights (corerights.com) is an example of an application that handles pure B2B blockchain-licensed music transactions. Core Rights is building a marketplace for licensing of music by venues, such as bars, restaurants, and retail stores, which pay performance royalties for music they play on their audio systems. Venues choose the music they want to play and take licenses to it; each license is represented as a smart contract with the rights holder on a blockchain. Core Rights is currently working with the Canadian PROs SOCAN (for compositions) and Re:Sound (for sound recordings) to build the first implementation of its marketplace in Canada.

dotBlockchain Music Project

The dotBlockchain Music Project (dotblockchainmusic.com) is a public benefit corporation[26] which is creating open-source technology to support a new file format for music called .bc (dotBlockchain), which will contain digital audio along with metadata that points to entries in blockchains denoting music rights transactions. dotBlockchain started out using the Bitcoin blockchain, but it is currently blockchain-agnostic. The technology includes protocols and interfaces to record and read transactions on .bc files on the blockchain.

dotBlockchain is based on the core concept of Minimum Viable Data (MVD). Instead of trying to create a large database schema that contains every piece of information that anyone would want to know about a musical work, it contains only just enough data to disambiguate the work and identify rights holders. Thus MVD is a radical departure from previous rights registry initiatives in that it contemplates distributed interoperability among existing databases, as described in the Introduction above.

At the time of this writing, the MVD is being defined by multi-stakeholder input. There are two versions of MVD: a very minimal one for registering a new work and a larger one for enabling rights transactions in the work.[27] Several rights administrators have agreed to make their data available to the project, including SOCAN, MediaNet (a "white label" wholesale DSP owned by SOCAN), Songtrust (an administrative service for music publishers), the indie artist distributor CD Baby, and the indie label aggregator FUGA (see p. 8).[28]

Open Music Initiative

Finally, the Open Music Initiative (OMI) is a new standards initiative that arose out of the Berklee College of Music's Rethink Music initiative and now also involves the MIT Media Lab, the design company IDEO, and the blockchain platform technology startup Context Labs. OMI is creating protocols for interoperability among existing databases, standards, and tools that will store transactions on a blockchain.[29]

Watermarking and Blockchains

All of the blockchain projects mentioned above have one thing in common: they all store associated transaction information on blockchains, but the music itself can exist outside the blockchain. Blockchains are not efficient enough today to store the digital content along with transaction information, and there is no compelling reason to do so anyway.

Music stored outside of a blockchain does not have the same level of security as transaction data stored in the blockchain. Information in digital media files themselves must have a comparable level of security.

Yet music stored outside the blockchain does not have the same level of security as the transaction data stored in the blockchain. To remedy this, it is necessary to give information in digital media files themselves a comparable level of security.

Linking Blockchain Transactions with Music Files

The way to do this is to create links between transactions on blockchains and the music files that are the subjects of the transactions, by putting an identifier in each transaction record that matches an identifier in each music file. This can be done if the identifier in the music file is robust and immutable enough, and if it is sufficiently unique for the application. In other words, identifiers must be associated with music files in ways that meet the criteria in Table 1 on p. 12 above: robustness, data flexibility, identifier reliability, and security.

There are two ways to meet these criteria: with encryption or with watermarks. With encryption, the entire file contents (music plus metadata) must be encrypted. The only way to get access to the contents is through software that only decrypts it under particular circumstances and for particular purposes.

The encryption approach can be secure, but it is also complex and cumbersome for the application that has to access the metadata and the music. For example, a user or service provider that wants to process or convert the format of the music (e.g., to another codec or bitrate) would have to use a special application that will decrypt the file, do the conversion, and preserve the integrity of the metadata.

Watermarking is the simplest and most flexible way of ensuring the integrity and persistence of identifiers embedded in digital audio files. Watermarking does not impede the use of the music in any way.

Watermarking is a much simpler and more flexible way of ensuring the integrity and persistence of identifiers embedded in digital audio files. Unlike encryption, watermarking does not impede the use of the music in any way. Identifiers embedded via watermarks are secure, just like data in a blockchain, and it's possible to make changes such as music format conversions while preserving the watermark.

Figure 7 shows a hypothetical blockchain with nodes denoting music rights transactions. Node 1 points to an encrypted file, File 1. The ID for that file is securely embedded in the file as header metadata. To play that file or to edit it (for post-production, transcoding, altering metadata, or other purposes) requires obtaining decryption keys and decrypting the file. Such applications would be more expensive, cumbersome to use and maintain, and most likely limited in functionality. The applications would also have to be trusted to be secure.

Node 2 points to File 2, a file with a watermark embedded in the file whose payload denotes its ID. The watermark could be embedded by a label and sent to a DSP, which might then transcode the audio to the format and bitrate it serves to users. It's possible to play and edit that file using generic applications that don't need to restrict functionality, be trusted to be secure, or rely on a third-party entity such as a cryptographic key provider. This is clearly a much simpler and less restrictive scheme for embedding identifiers securely.

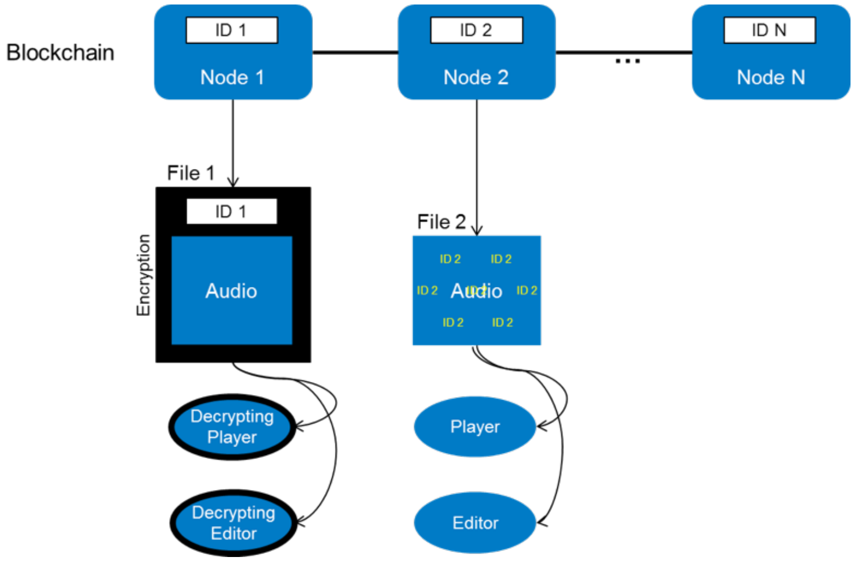

Figure 7 above: Watermarking and encryption both enable IDs to be securely linked from transactions on a blockchain to the music files themselves, but watermarking is a simpler and more flexible scheme.

Embedded Identifiers and Blockchain Applications for Music

How can embedded identifiers help enable blockchain applications for music? Here's one example: Core Rights (or a company working with it) could supply music files that are cleared for its venue licensing marketplace, which venues could play whenever they want. The files could contain watermarks that identify them as Core Rights files. A Core Rights blockchain transaction record would include information about the licensee (venue) and the ISRC of the licensed recording, as well as information identifying the recording's underlying composition. The watermark in each music file could indicate all that information. A player app could read the watermark and deposit a transaction on a blockchain in real time, and/or the watermarks could be detected and matched to transactions on the blockchain as part of a periodic auditing process.[30]

Watermarks embedded in music files can facilitate licensing of stems or samples in remixes and mashups through blockchain transactions.

Another example could be the use of "found" music files (see p. 9) in remixes. A producer could use an app that reads the watermark in a music file, deposits a licensing transaction on a blockchain, and then provides stems (individual tracks) to the producer for remixing. The service provider behind the app could then pick up the transaction from the blockchain and process the appropriate royalties. Finally, the producer would complete the remix and submit it through the app to the service provider, which would return it watermarked with a new identifier, which the service provider would associate with identifiers for the stems. This would enable the producer to protect and license rights to the new remix: information about the stems used in the remix is stored on the blockchain, so the service provider can process the required rights and royalty transactions on the stems whenever anyone licenses the remix.

More generally, there is much discussion currently – such as within the Open Music Initiative – about processing DSPs' royalty transactions on blockchains. For example, whenever someone plays music through an interactive streaming service such as Apple Music or Spotify, it would deposit a transaction on a blockchain so that all applicable royalties can be paid to rights holders. The same identifiers that are stored in blockchain entries can also be embedded as watermark payloads to the files supplied to those DSPs. Entities that are owed royalties, such as record labels, can extract identifiers from those files and get access to transaction information from the blockchain without any need to contact the DSPs directly.

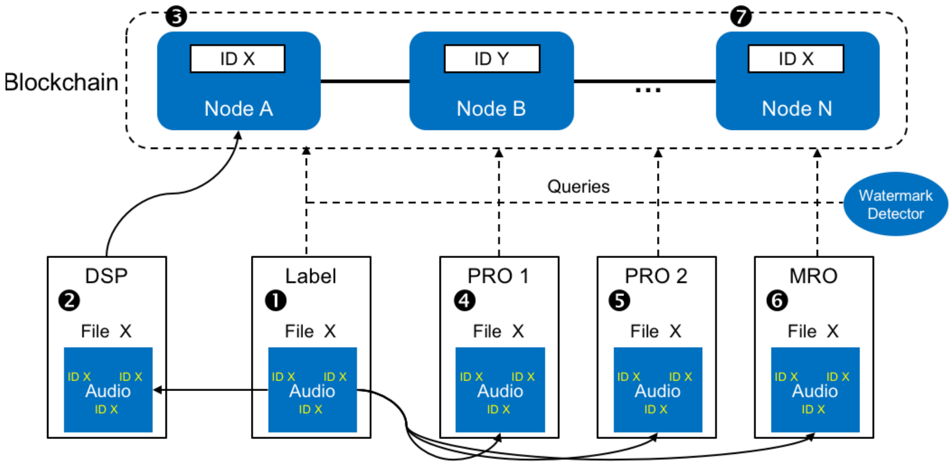

Figure 8 above: IDs embedded in music files can be used to query a blockchain for royalty transactions resulting from plays through DSPs.

Figure 8 shows this. A label (**1**) sends a music file, File X, to a DSP (**2**). File X has the file's ID, ID X, embedded as a watermark. One of the DSP's users plays the track, and the DSP deposits a transaction on the blockchain containing ID X (**3**). The label (**1**) also sends copies of the file with the embedded ID to two PROs (e.g., ASCAP and SoundExchange (**4** and **5**)) and an MRO (e.g., HFA (**6**)). The label, PROs, and MRO can all query the blockchain, using the ID embedded in File X, to find transactions involving File X. The blockchain in Figure 8 indicates two such transactions: one is from the DSP in the figure (**3**), while the other (**7**) could have come from another DSP. DSPs can deposit the transactions in real time, while the royalty processing organizations can query the blockchain for them anytime.

Whenever someone plays music through an interactive streaming service, the service could deposit a transaction on a blockchain so that all applicable royalties can be paid to rights holders.

This would be a simple and secure alternative to complex metadata standards and monolithic databases. Such a scheme is compatible with the architecture of Dot Blockchain Music and the vision of OMI.

Conclusion

As the field of blockchain applications for music expands, the opportunities to use information embedded into recorded music files that aren't stored on blockchains will expand, too. The initial blockchain applications for music should fall into two categories. One is niche applications that create new revenue opportunities for music rights licensing or greatly expand existing ones. Core Rights is an example of this; it should increase the size of the venue licensing market for music.

The other category of blockchain applications is automation of royalty processing for large DSPs. DSPs have become the "big boys" of the music industry, as their aggregate revenues (from users and advertisers) now exceed that of record labels and music publishers combined.

DSPs currently face two problems in music royalty transaction processing that blockchain technology can help solve. One is the inefficiency of processing many different types of music transactions from a very large number of rights holders. DSPs currently get information from rights holders in many different formats, which all have to be processed and converted. The use of blockchain technology, while not a solution in itself, helps motivate the use of standards that promote consistency and efficiency.

The other problem is incomplete or erroneous data that occurs when so many different entities and data sources are involved. DSPs are motivated to reduce not only operating costs but also the legal risks associated with potential improper royalty payments. Blockchain technology can't solve the "garbage in, garbage out" problem, but it can help by eliminating the redundancies that arise from copying data from one place to another and making it easier to trace errors and gaps to single sources.

In addition, DSPs have more recent IT infrastructure that is more likely to be easier to integrate with blockchain-based solutions and standards than those of traditional PROs or labels. Therefore the largest early adopters of blockchain-related technology for music are likely to be DSPs. The other likely early adopters are service providers that handle royalty processing for music publishers as well as DSPs – both existing and new ones.

In general, blockchain technology helps by streamlining processes and bringing energy, technical talent, and investment to adoption of standards, through initiatives such as the Dot Blockchain Music Project and the OMI.

Watermarking should be a key component of blockchain-related infrastructure for digital music. It ensures that metadata associated with music files has the same degree of persistence, reliability and security as information stored in blockchains, and it does so in a lightweight, flexible, and interoperable way. Watermarking should find its proper place as the music industry continues its transition to the digital age.

About Digimarc

Digimarc Corporation (NASDAQ: DMRC) is a pioneer in the automatic identification of everyday objects such as product packaging and virtually any media, including print, images and audio. Based on patented technologies including the Intuitive Computing Platform (ICP™) and Digimarc Barcode, Digimarc provides innovative and comprehensive automatic recognition technologies to simplify search, and transform information discovery through unparalleled reliability, efficiency and security.

Digimarc has a renowned global patent portfolio, which includes over 1,100 granted and pending patents. These innovations include state-of-the-art identification technology, such as Digimarc's audio watermarking SDKs, applications and services, which apply an imperceptible identity to music and audio and provide fast, reliable and efficient detection in diverse environments spanning monitoring networks and mobile applications. Digimarc's audio watermarks are leveraged by SourceAudio in millions of uniquely identified tracks for production music monitoring. In addition, Rovio, the creator of "The Angry Birds Movie," utilized Digimarc Barcode in the film and DVD release to allow interaction by the Angry Birds Action! app. In 2015, Digimarc received an Emmy Award for Steganographic Technologies for Audio/Video for its excellence in embedding information in media to facilitate accurate identification in monitoring, measurement and interactive applications.

Digimarc is based in Beaverton, Oregon, with technologies deployed by media and entertainment companies, major retailers and consumer brands, global banks, U.S. states, and professional sports franchises, among others. For more information and the latest news, please visit www.digimarc.com and follow on Twitter at @Digimarc.

About the Author

Bill Rosenblatt founded GiantSteps Media Technology Strategies in 2000. He is the author of several books, including Digital Rights Management: Business and Technology (John Wiley & Sons, 2001), and several white papers on digital rights and content management technologies. He is a contributor to Forbes on digital media technologies and business models. He has served as a technical expert in litigation and public policy initiatives related to digital copyright. He is editor of the blog Copyright and Technology (**www.copyrightandtechnology.com**), Program Chair of the Copyright and Technology Conferences (**www.copyrightandtechconf.com**), and a member of the Open Music Initiative.

About GiantSteps Media Technology Strategies

GiantSteps Media Technology Strategies is a management consultancy focused on the content industries that help its clients achieve growth through market intelligence and expertise in business strategy and technology architecture. GiantSteps' clients have included branded content providers, digital media technology vendors ranging from early-stage startups to Global 500 firms, and technology public policy entities in the United States and Europe. For more information, please visit **www.giantstepsmts.com**.

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Media Technology Strategies

Endnotes

1. See http://www.thembj.org/2015/08/grds-failure/ for a good overview of these efforts and their failures.

2. Most of the information in this section is particular to the United States, though copyright laws and music business practices in other industrialized countries are often conceptually similar.

3. Whereas all composers have to use a publisher to administer composition rights, a recording artist doesn't strictly have to have a label to administer sound recording rights.

4. It is possible for a songwriter to be affiliated with one PRO and to publish music through a publisher that is affiliated with a different PRO.

5. Copyright holders' performance rights on sound recordings are limited to "digital audio transmission[s]", which are the relevant cases for purposes of this white paper.

6. Some recording artists retain ownership of their copyrights. Many independent artists work with indie distributors (see p. 8), which let them keep all of their sound recording rights.

7. Services such as Pandora that allow users to influence and customize music programming via "thumbs up/thumbs down" type features qualify as noninteractive.

8. Some DSPs, such as Spotify and Google Play Music, offer both interactive and noninteractive streaming.

9. Some of these royalty payments are mandated by law, while others are specified in private agreements between DSPs and rights administrators such as labels, PROs, and publishers. Details are beyond the scope of this white paper, but for a highly useful and detailed discussion, see the U.S. Copyright Office report Copyright and the Music Marketplace at https://www.copyright.gov/policy/musiclicensingstudy/copyright-and-the-music-marketplace.pdf.

10. Some recordings, such as "mashups," can embody more than one composition; see note 17 below for an example.

11. AFM (American Federation of Musicians) and SAG-AFTRA (Screen Actors Guild-American Federation of Television and Radio Artists) are labor unions that pay royalties to musicians and backing vocalists.

12. See http://isrc.ifpi.org. The ISRC is administered by IFPI, the international umbrella trade organization for the recording industry.

13. See http://www.iswc.org. The ISWC is administered by CISAC, the international umbrella trade organization for composers and their rights administrators, a separate organization from IFPI.

14. See http://www.isni.org.

15. Note that this is potentially an M-to-N mapping. A composition can have multiple recordings (think "Yesterday" by Lennon & McCartney), or a recording can embody multiple compositions (think Danger Mouse's The Grey Album, which contains mashups of the Beatles and Jay-Z).

16. For example, ASCAP's database lists over 600 different compositions with the title "You and I", each of which has different composers.

17. See http://www.billboard.com/biz/articles/news/publishing/6114215/nmpa-puts-us-publishing-revenues-at-22-billion-annually.

18. For example, SoundExchange maintains a publicly searchable ISRC database at https://isrc.soundexchange.com/#!/search.

19. The dotBlockchain Music Project (see p. 16) defines a Minimum Viable Data set for registration purposes consisting of composition title, master recording title, composer name(s), and artist name(s). The difference between this and the scheme discussed here is that we assume that a work is already distributed through a label and registered with a PRO, whereas Dot Blockchain does not.

20. PRO databases often have at least some information about other PROs and publishers with which co-composers are affiliated. Thus, querying multiple PROs where there are multiple composers can yield redundant information – which should confirm the identities of rights holders but could also turn up errors.

21. Some may also argue that relying on PRO databases in this manner is not reliable enough and that it is necessary to include a complete list of publishers in metadata associated with a digital music file.

22. See http://id3.org/.

23. A couple of startup companies built DRM-like solutions for encrypting digital music files as they went from record labels to third-party post-production and distribution companies. These were rejected as too restrictive and inconvenient.

24. The academic literature often uses the term "perceptual hash" for fingerprinting.

25. See http://www.ddex.net.

26. A corporate structure that is for-profit but designed to benefit the public as well as shareholders, known in the UK as a QUANGO. See https://en.wikipedia.org/wiki/Public-benefit_corporation. Several public transportation companies are organized as public benefit corporations.

27. See https://medium.com/dotblockchainmusic/the-dotblockchain-music-project-update-7-minimum-viable-data-doc-561fdfadd5eb.

28. See http://www.prnewswire.com/news-releases/dotblockchain-music-project-announces-first-industry-partners-300400206.html.

29. See http://openmusicinitiative.org/.

30. This is analogous to sampling schemes that certain PROs use to determine music played on broadcast radio for royalty distribution purposes. Some of these schemes use fingerprinting (see p. 13); watermarks would be more accurate and flexible.

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