**ISO/IEC JTC 1/SC 29/WG 03 N0979**

**ISO/IEC JTC 1/SC 29/WG 03  
MPEG Systems   
Convenorship: KATS (Korea, Republic of)**

**Document type:** Output Document

**Title:** WD of ISO/IEC 23000-23 Decentralized Media Rights Application Format

**Status:** Approved

**Date of document:** 2023-07-19

**Source:** ISO/IEC JTC 1/SC 29/WG 03

**Expected action:** None

**Action due date:** None

**No. of pages:**  28 (with cover page)

**Email of Convenor:** young.L @ samsung . com

**Committee URL:** <https://isotc.iso.org/livelink/livelink/open/jtc1sc29wg3>

**INTERNATIONAL ORGANISATION FOR STANDARDISATION**

**ORGANISATION INTERNATIONALE DE NORMALISATION**

**ISO/IEC JTC 1/SC 29/WG 03 MPEG SYSTEMS**

**ISO/IEC JTC 1/SC 29/WG 03 N0979**

**July 2023, Geneva (CH)**

|  |  |
| --- | --- |
| **Title** | **WD of ISO/IEC 23000-23 Decentralized Media Rights Application Format** |
| **Source** | **WG 03, MPEG Systems** |
| **Status** | **Approved** |
| **Serial Number** | **22973** |

**ISO/IEC JTC 1/SC 29/WG 03 N0979**

Date:   2023-07-21

**ISO/IEC 23000-23:2023**

ISO/IEC JTC 1/SC 29/WG 03

Secretariat:

**Information technology — Multimedia application format (MPEG-A) — Part 23: Decentralized media rights application format**

*Élément introductif — Élément central — Partie 4: Titre de la partie*

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This document was prepared by Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 29, *Coding of audio, picture, multimedia and hypermedia information*.

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**Introduction**

Copyright legislation has continuously evolved so that fair, timely and transparent revenues are returned to artists and rights holders, e.g., US Music Modernization Act and EU Directive on Copyright in the Digital Single Market. Effective IP rights management in the digital environment is key to support the competitiveness of creative industries.  Creative companies and SMEs need to be empowered to make better decisions and deploy more advanced solutions based on insights gleaned from data. ISO/IEC 21000-23 Smart Contracts for Media supported by rich semantic copyright models can be handy when data-based decisions need to be derived by evidence and logic, leading to new business models that can be efficiently deployed on decentralized digital media platforms.

With respect to the latter, towards **enabling** a **fairer marketplace for rights holders**and remuneration of authors and performers, this standard will provide the means (e.g., technologies and application programming interfaces) for a decentralized media rights application format based on MPEG technologies (e.g., audio-visual codecs, file formats, streaming protocols, and smart contracts) and non-MPEG technologies (e.g., DLTs, content and creator IDs). In that way, application developers would be able to develop interoperable decentralized music and video applications.

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**Information technology — Multimedia application format (MPEG-A) — Part 23: Decentralized media rights application format**

Ed. note: This is not the final Working Draft (WD).

# Scope

This standard will provide the means (e.g., technologies and application programming interfaces) for a decentralized media rights application format based on MPEG technologies (e.g., audio-visual codecs, file formats, streaming protocols, and smart contracts) and non-MPEG technologies (e.g., DLTs, content and creator IDs).

# Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

*ISO 15836, Information and documentation – The Dublin Core metadata element set.*

*ISO/IEC 21000-3, Information technology – Multimedia framework (MPEG-21) – Digital Item Identifier.*

*ISO/IEC 21000-19, Information technology – Multimedia framework (MPEG-21) – Media Value Chain Ontology.*

*ISO/IEC 21000-19/AMD1, Information Technology – Multimedia Framework (MPEG-21) – Part 19: Media Value Chain Ontology / AMD 1 Extensions on Time-Segments and Multi-Track Audio.*

*ISO/IEC 21000-20 (2nd Ed), Information technology – Multimedia framework (MPEG-21) – Contract Expression Language.*

*ISO/IEC 21000-21 (2nd Ed), Information technology – Multimedia framework (MPEG-21) – Media Contract Ontology.*

*ISO/IEC 21000-23, Information technology – Multimedia framework (MPEG-21) – Smart Contract for Media.*

*ISO 27729:2012 Information and documentation – International standard name identifier (ISNI).*

*ISO/IEC 14496-12, Information technology – Coding of audio-visual objects – Part 12: ISO base media file format.*

*ISO/IEC 23000-12, Information technology – Multimedia application format (MPEG-A) – Part 12: Interactive music application format.*

*ISO/IEC 23000-19 Information technology – Multimedia application format (MPEG-A) – Part 19: Common media application format (CMAF) for segmented media.*

*ISO/IEC 23009-1, Information technology – Dynamic adaptive streaming over HTTP (DASH) – Part 1: Media presentation description and segment formats.*

*ISO/CD 24138.2, Information and documentation – International Standard Content Code (ISCC)*

# Terms, definitions, symbols, and abbreviated terms

## Terms and Definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>

- IEC Electropedia: available at <https://www.electropedia.org/>

## 

**decentralized identifier**  
type of identifier that enables verifiable, decentralized digital identity. A decentralized identifier refers to any subject (e.g., a person, organisation, thing, data model, abstract entity, etc.) as determined by the controller of the DID.

## 

**metadata**

information given to describe or help use other information. In the case of copyright, one distinguishes between: (i) rights management information comprises identification metadata and rights metadata; (ii) descriptive metadata for search and enjoyment of content; (iii) usage metadata for a fair trade of content; (iv) administrative metadata to trust all other metadata.

## 

**token**

object stored in a DLT and managed through one or more smart contracts, representing unique tangible or intangible media assets, possessions, and accountable items.

## 

**fungible token**

token being changeable with other tokens

## 

**non-fungible token**

token being non interchangeable with other tokens

## 

**self-sovereign identity**

paradigm that brings forward the concept that subjects must have complete control over the data that identify them, namely, being able to decide how much, which, and with whom to share them.

## Abbreviated terms

**CEL** contract expression language

**DID** decentralized identifier

**MCO** media contract ontology

**MVCO** media value chain ontology

**NFT** non-fungible token

**SSI** self-sovereign identity

# Conventions

# Overview

This section gives a brief overview of the components needed for such a Decentralized Media Rights Application Format based on MPEG and non-MPEG standards.

Diagram

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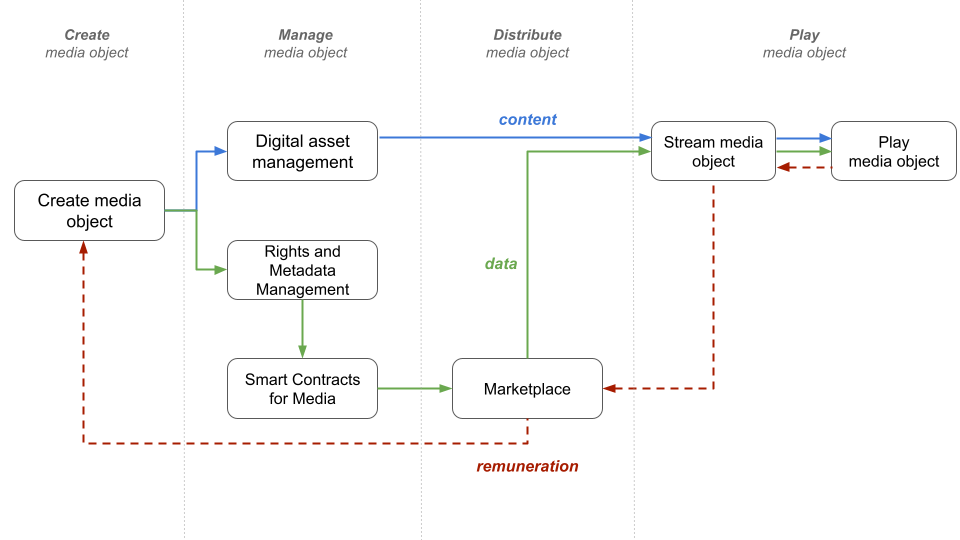
**Figure 1:** Decentralized Media Rights Application Format architecture overview

The Decentralized Media Rights Application Format represents a set of protocols, rules, and frameworks designed to facilitate the seamless exchange of media assets, ownership rights, and revenue sharing in a decentralized manner. By integrating DLT, smart contracts, and tokens, the Decentralized Media Rights Application Format standard enables media creators, distributors, and consumers to interact directly, reducing the need for intermediaries and introducing new levels of transparency, efficiency, and fairness.

At its core, the Decentralized Media Rights Application Format aims to address some of the key challenges faced by the media industry today. These challenges include complex licensing agreements, revenue distribution inefficiencies and limited access to global markets. By establishing a decentralized infrastructure, this application format empowers creators by giving them more control over their intellectual property, allowing for direct monetization opportunities and reducing the dependence on centralized intermediaries.

Furthermore, the Decentralized Media Rights Application Format paves the way to innovation and collaboration within the media ecosystem. It opens up new possibilities for content curation, remixing, and derivative works, encouraging the development of communities and ecosystems around specific media assets.

One of the key benefits of the Decentralized Media Rights Application Format is its ability to enable seamless interoperability between different media applications and platforms. By defining common data formats and communication protocols, it allows for the exchange and integration of media content across various decentralized applications. This interoperability breaks down silos and empowers users to access and engage with content from multiple sources, fostering a more open and connected media ecosystem.



**Figure 2:** Outline of the data flows necessary to assure the remuneration of creators

The Decentralized Media Rights Application Format is a comprehensive framework that focuses on facilitating the seamless flow of data to ensure fair, appropriate, proportionate, and transparent remuneration for creators. It encompasses four crucial steps, each playing a vital role in evolving the media rights landscape:

1. **Create and manage media objects**: This initial step involves empowering creators to create and manage media objects within the Decentralized Media Rights Application Format. This step involves providing tools, interfaces, and protocols that enable content creators to easily create, upload, store, and organize their media assets on decentralized platforms. By incorporating user-friendly interfaces and intuitive workflows, the application format streamlines the process of media creation and management, allowing creators to efficiently publish and maintain their content.
2. **Rights and metadata management**: This initial step involves the efficient management of rights and metadata associated with media assets. It encompasses processes such as copyright registration, ownership verification, and the inclusion of relevant information like licensing terms, usage restrictions, and attribution details. By establishing clear and reliable rights and metadata management mechanisms, the Decentralized Media Rights Application Format ensures that creators' intellectual property is accurately represented and protected.
3. **Decentralized execution**: Building upon a decentralized infrastructure, the Decentralized Media Rights Application Format leverages various technologies including DLTs, smart contracts, and tokens to facilitate the execution of media rights agreements. These decentralized mechanisms enable automated and tamper-proof enforcement of licensing terms, royalties, and revenue-sharing agreements. Through the use of the Smart Contracts for Media, creators can receive immediate and transparent compensation based on predefined conditions and revenue distribution models based on the MPEG-21 framework.
4. **Marketplace**: The Decentralized Media Rights Application Format enables the building of marketplaces where media assets can be discovered, traded, and licensed directly between creators, distributors, and consumers. This marketplace provides a platform for content creators to showcase their work, negotiate licensing deals, and receive fair compensation for their contributions. By reducing intermediaries and enabling direct peer-to-peer transactions, the application format promotes a more efficient, inclusive, and economically viable ecosystem for media rights exchange.
5. **Streaming & playing**: In the final step, the Decentralized Media Rights Application Format addresses the crucial aspect of streaming and playing media content. By integrating with existing streaming standards and platforms, the application format ensures secure and seamless access to licensed media assets. It promotes the use of digital wallets and token-based systems to enable frictionless payments for streaming services, ensuring that creators receive appropriate remuneration based on consumption metrics.

# Create and manage media objects

## Music authoring tools

Widespread adoption of interactive music services and applications (remixing, karaoke, and collaborative music creation) - thanks to IM AF (ISO/IEC 23000-12) raises the issue of intellectual property (IP) rights monitoring in such applications, for fair and transparent payment of royalties to artists and rights holders. The MVCO (ISO/IEC 21000-19) facilitates rights tracking for such services by capturing user roles and their permissible actions on a particular IP asset. While the AVCO (ISO/IEC 21000-19/AMD1) facilitates transparent IP rights management even when reuse of audio IP assets is involved, such as, tracks or even segments of them in new derivative works.

Furthermore, Mixrights is an on-line Javascript application based on IM AF (ISO/IEC 23000-12). It works entirely in the browser and operates much like a typical desktop document-editing application. IM AF files can be loaded by simply dropping them on the browser window. Then, tracks can either be removed or new tracks can be added by dropping audio files in the browser. Images and lyrics can also be added in the same way and mixing presets can be edited by playing the sequence and recording fader movements. Mixrights users can share their musical creations by uploading them to the server and sharing the links, e.g., in social networks. Users can also create new mixes or karaoke versions of existing songs (derivative works) and instantly share them. Mixrights keeps a count of the number of times a user-mix or karaoke version has been played helping users develop reputation. Mixrights software can be used for seamless integration with ISO/IEC 21000-23 Smart Contracts for Media for rights tracking towards fair payment of royalties.

## Open Music Initiative (on-demand streaming, digital sale, and radio broadcast)

These use cases are about how the money flows back to songwriters, artists, publishers, and labels, when their music is webcast or streamed on interactive services, sold on digital platforms, and played on radio. For interactive streams and digital sales, the money flows depend on what entity negotiated the license (e.g., record labels having a direct deal with services, record labels represented by a digital aggregator/distributor and artists owning recording copyrights and using distribution services), while for radio and radio-like services, blanket licenses determine who gets paid and how much. MPEG-21 CEL/MCO contracts are provided for each of these use cases in [1]. This use case has been concluded with ISO/IEC 21000-23 Smart Contracts for Media.

## Broadcasting operations

The MCO (ISO/IEC 21000-21) provides the means to express the rights for exploiting media content, as it is typical among audio-visual production companies and broadcasters. In such a context, the most used commonly rights for media exploitation are public performance (e.g., where the public is present), fixation (e.g., when a performance is recorded on a tangible medium) and communication to the public (e.g., where the public is reached by means of a communication technology). As in narrative contracts, these exploitation rights might be associated with a wide set of conditions (e.g., number of broadcast transmissions, time periods, territories, languages, exclusivity, royalty percentages), modalities (e.g., linear/broadcast and non-linear/broadband) and access policies (e.g., free of charge, subscription, pay per view). This use case is more suitable for production companies and broadcasters deploying technologies such as CMAF & DASH.

# Rights and metadata management

Rights metadata management is built around the the ISO/IEC 21000-23 Smart Contracts for Media.

The role of rights metadata management is to allow rightsholders to declare their rights and rights users to search for rights. Rights users will then license, distribute, and remunerate content. Therefore, one must be able to:

* Store identification metadata and rights metadata including machine-readable royalty splits, as well as standard terms and conditions. Identification metadata answering the questions: what is what, who is who; Rights metadata answering the questions: who did what, who owns what, what can we do with that.
* Manage the ex-ante (before distribution) machine-readable propagation of royalty splits (for remuneration) and terms and conditions (for licensing) throughout the dynamic and complex structure of contributions to a media end product. The data required for distribution and remuneration, i.e., the data required for a smart contract, is interlinked in the licensing statement: “Licensor (Partya) gives Licensee (Partyb) the Licencel to perform the Actions A1 to n over the IP Entities1 to m under the Terms T1 to k”.

Metadata management includes the capture of contributors and their contributions, the ingestion of rights data, the handling of ownership or availability conflicts, and the query of rights data. In the following, these functionalities are briefly described:

* the capture of rights data to identify who did what as close as possible to the moment of creation, which may require forms of (semi-)automation such as plug-ins
* the ingestion of rights data whereby the attribution creator ABC created content XYZ should be attested, e.g., through verifiable credentials, and must be accompanied by rights management information on ownership splits and standard terms & conditions
* the handling of ownership or availability conflicts, whereby records must be reconciled, matched and/or deduplicated, conflicts must be identified, parties must be notified, and resolution must be monitored
* the query of rights data allowing (a) a digital service provider to find the rights management information pertaining to content uploaded on its platform, and (b) potential rights users (e.g., filmmakers) to find content (e.g., music) relevant to their purpose as well as the related rights management information.

## Rights registration

Media object rights registration refers to the process of formally documenting and registering the rights associated with a particular media object within the context of the Decentralized Media Rights Application Format. It involves the identification, categorization, and registration of various rights, such as copyright, ownership, licensing terms, and usage restrictions, that are associated with a specific media asset.

When a media object is created or uploaded to the decentralized ecosystem, the rights registration process ensures that the creator's intellectual property rights are properly acknowledged and protected. It involves capturing detailed information about the rights associated with the media object, including the creator's name, date of creation, copyright registration details, and any relevant licensing terms or usage agreements.

In the following, “content”, aka media object, refers to an abstract right-protected Creative Work manifested in Media Files; “creator” refers to authors, performers, and contributors.

### **Relations to MPEG standards**

Ed note: This section is tentative and needs to be revised

The content and user entities can be placed in the context of the MPEG-M and MPEG-21 Smart Contract for Media standards. The following tables describe the relations between action, entities, data formats and rights representation in the context of both standards.

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**Table 1**: Actions and entities of rights registration according to MPEG-M

The content and user entities can act in different ways with reference to the scope of the MPEG-M, as shown in Tables 1 and 2.



**Table 2**: Actions, entities, and data formats of rights registration

With regards to the Smart Contracts for Media, Table 3 shows what Application Programming Interfaces (APIs)’s objects are used to represent the user (party) and content (object).



**Table 3**: Rights registration entities in the Smart Contracts for Media

### **Rights Registration Scenario**

1. A Creator, or a declarer, access Rights and Metadata Management, uploads a Media File, and generates a Content Identification.
2. The declarer identifies the Creators of the Creative Work.
3. The declarer describes Creative Work and Creators according to MPEG-21 CEL/MCO schemas and ontologies.
4. The declarer enters the Creators’ splits. If Rightsholders differ from Creators, the declarer also enters the Rightsholders’ splits.
5. The declarer enters the narrated standard terms and conditions.
6. The rights are registered. The immutable binding “Declarer-Content” is stored on a DLT. The Declarer is identified by the wallet address that signs the declaring transaction. The Content is identified by an ownerless similarity-preserving digital content fingerprint. The block that includes the declaration is implicitly and unforgeably timestamped. The on-chain data can also include the smart contract address that facilitates the transaction and a link to off-chain metadata about the declared Content.
7. Splits and standard terms and conditions are stored off-chain according to MPEG-21 CEL/MCO.

## Content and Creator Identification

The following is a list of possible identification standards that are used in the Decentralized Media Rights Application Format to identify content and creators.

* *ISO/IEC 21000-3 Digital Item Identification (DII)* content identification is a fundamental component of any asset trade system. An asset identifier can be random so long as it can also be discovered by alternate IDs such as the International Standard Recording Code (ISRC) or the International Standard Work Code (ISWC) or other internal fields or keywords. These alternate IDs enable two or more organizations to discover and share a common identifier for an asset. The MPEG-21 Digital Item Identification provides a simple, extensible, and interoperable mechanism on how to integrate in music trade systems not only existing but even future alternate identification schemes by facilitating the elements: (i) Identifier; and (ii) RelatedIdentifier.
* *ISO 27729 International Standard Name Identifier (ISNI)* is in use by numerous libraries, publishers, databases, and rights management organizations around the world. It is used to uniquely identify persons and organizations involved in creative activities, as well as public personas of both, such as pseudonyms, stage names, record labels or publishing imprints. As an open standard, ISNI is not a proprietary "walled garden" - it is diffused widely on the open web and is a critical component in Linked Data and Semantic Web applications. Several mechanisms are available for interacting with the ISNI database, including manual interaction, batch processing and real-time API requests and responses. ISNI supports a number of data formats, both for submission to the database and for outputs from the system.

For data input operations, primarily related to searches, to matching between source databases and ISNI, and to ISNI assignment requests, ISNI-XML is the preferred format. It is also possible to submit tab-delimited CSV information for batch assignment requests and matching. For data output from the ISNI system, ISNI-XML is again the preferred and richest format available. Additionally, as a product of ISNI’s work on Linked Data, it is also possible to access a subset of the data available in either RDF/XML or JSON-LD formats.

* *ISO WD 24138 International Standard Content Code (ISCC)* identifiers are generated algorithmically from the content itself. Content files are processed to build the identifier. The ISCC does not have to be manually assigned, nor does it have to be carried around or embedded within the content. The content itself is the source and authority of the ISCC. The ISCC is a unique, hierarchically structured, composite identifier. It is built from a generic and balanced mix of content-derived, locality-sensitive, and similarity-preserving hashes generated from metadata and content. The ISCC has been accepted by ISO as a full work item ISO/AWI 24138 - International Standard Content Code and is currently being standardized at TC 46/SC 9/WG 18 - Digital-Content-Based Identification.
* *EIP-721 Non-Fungible Token (NFT)* is a way of proving that a digital item is the only one of its kind in existence and therefore cannot be copied or reproduced without the owner's knowledge and consent. NFTs can be thought of as a digital certificate of authenticity. They are bought and sold online and represent digital proof of ownership of any given item. NFTs are securely recorded on a blockchain.However, the legal rights conveyed by an NFT can be uncertain. ERC-721 was the first standard for representing non-fungible digital assets on the Ethereum blockchain. With respect to MPEG-21 CEL/MCO schemas and ontologies, an IP entity is the representation of an asset, and the reference to this asset can be stored in a DLT. This representation of an asset may be serialized according to the concept of NFTs. Moreover, a deontic expression encompasses the properties of an agreed machine-readable contract clause regulating the actions of the parties, e.g., obligations, permissions, and prohibitions. This representation of a clause may also be connected to the concept of NFTs.
* W3C Decentralized Identifiers (DIDs) are a type of globally unique identifier. They are designed to enable individuals and organizations to generate their own identifiers using systems they trust. These new identifiers enable entities to prove control over them by authenticating using cryptographic proofs such as digital signatures. Since the generation and assertion of Decentralized Identifiers is entity-controlled, each entity can have as many DIDs as necessary to maintain their desired separation of identities, personas, and interactions. The use of these identifiers can be scoped appropriately to different contexts. They support interactions with other people, institutions, or systems that require entities to identify themselves, or things they control, while providing control over how much personal or private data should be revealed, all without depending on a central authority to guarantee the continued existence of the identifier.

In an SSI system, holders generate, and control unique identifiers called decentralized identifiers. Most SSI systems are decentralized, where the credentials are managed using crypto wallets and verified using public-key cryptography anchored on a distributed ledger. The European Union is creating an eIDAS compatible European Self-Sovereign Identity Framework (ESSIF). The ESSIF makes use of decentralized identifiers (DIDs) and the European Blockchain Services Infrastructure (EBSI).

* The Creative Passport (CP) is a verified digital ID for music makers, where they can access, update, and manage verified information about themselves and their works, and share it with others. Born out of think-and do-tank Mycelia, driven by a community of creatives, technologists, and industry champions. That is, having one decentralized hub where artists can upload and verify their data, while also connecting all of their existing external IDs in one place, will open up new opportunities and make the whole process of sourcing information and making payments much more controllable and transparent.

Creative Passport is based on OpenID Connect. The latter is a simple identity layer on top of the OAuth 2.0 protocol. It allows clients to verify the identity of the end-user based on the authentication performed by an authorization server, as well as to obtain basic profile information about the end-user in an interoperable and REST-like manner.

OpenID Connect allows clients of all types, including web-based, mobile, and javascript clients, to request and receive information about authenticated sessions and end-users. The specification suite is extensible, allowing participants to use optional features such as encryption of identity data, discovery of OpenID providers, and session management, when it makes sense for them.

# Decentralized Execution

The decentralized applications that are possible to build on top of DLTs thanks to smart contracts, exploit the verifiability of information stored on the distributed ledger and authentication based only on cryptographic primitives. This new kind of application created the need for standardized ways of representing information on DLTs. In the context of the MPEG-21 framework, DLTs and smart contracts have been placed at the center of the Smart Contract for Media specification.

## MPEG-21 Framework and the Smart Contract for Media

The MPEG-21 framework facilitates the representation in a machine processable way, the life cycle (aka value chain) and contracting of Intellectual Property (IP) entities. The MPEG-21 Smart Contract for Media builds on top of several MPEG-21 framework standards.

* *ISO/IEC 21000-19 Media Value Chain Ontology (MVCO)* facilitates the description of the media value chain and rights tracking for fair and transparent royalties’ payment by capturing User roles and their permissible actions on a particular IP Entity. The relationship between a User and a particular IP Entity type (e.g., work, adaptation, product, copy) is specified through the concept of role. The Actions that a User takes on a given IP Entity determine the role of that User with respect to the IP Entity in question. Users get roles (e.g., creator, adaptor, producer, end-user) that attribute them rights over Actions (e.g., create work, make adaptation, produce, distribute, synchronize) that can be exercised on specific IP entities. Any given User may take on any number of roles within a given value chain. These relations are shown in Figure 3. Furthermore, it enables music navigation based on IP rights through their visualization as co-author graphs revealing collaborations and influences among artists.

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**Figure 3**: Relations between IP Entities, Users, and Actions

* *ISO/IEC 21000-19/AMD1 Audio Value Chain Ontology (AVCO)* facilitates transparent IP rights management even when content reuse is involved. Widespread adoption of interactive music services (remixing, karaoke, and collaborative music creation) - thanks to IM AF/STEMS - raises the issue of rights monitoring when reuse of audio IP entities is involved, such as, tracks or even segments of them in new derivative works. The Audio Value Chain Ontology addresses this issue by extending MVCO functionality related to description of composite IP entities in the audio domain, whereby the components of a given IP Entity can be located in time, and for the case of multi-track audio, associated with specific tracks. The introduction of an additional 'reuse' action enables querying and granting permissions for the reuse of existing IP entities in order to create new derivative composite IP entities.
* *ISO/IEC 21000-21 Media Contract Ontology (MCO)* facilitates the conversion of narrative contracts to digital ones. It consists of a core model, which provides the elements for the creation of generic deontic statements encompassing the concepts of permission, prohibition, and obligation, and two extensions: (i) exploitation of IP Rights, e.g., licensing for broadcasting or public performance; (ii) payments and notifications, e.g., royalties’ splits between rights holders and currency conversions.
* *ISO/IEC 21000-20 Contract Expression Language (CEL)* supports the same functionality as the Media Contract Ontology (MCO) but expressed by XML schemas instead of RDF ontologies.
* *ISO/IEC 21000-23 Smart Contracts for Media (SCM)* provides the means (e.g., application programming interfaces) for converting MPEG-21 XML and RDF media contracts (ISO/IEC 21000-19 Media Value Chain Ontology, ISO/IEC 21000-19/AMD1 Audio Value Chain Ontology, ISO/IEC 21000-20 (2nd Ed) Contract Expression Language and ISO/IEC 21000-21 (2nd Ed) Media Contract Ontology) to smart contracts that can be executed on existing DLT environments. This standard assists the media industry in achieving effective interoperability for the exchange of verified contractual data between different DLTs. In this way, it will increase trust among the stakeholders for sharing high-value data (e.g., music rights) in the ecosystem. Another important feature of this standard is that it offers the possibility to persistently bind the clauses of a smart contract to their corresponding ones of a narrative contract. In this way, each party signing an ISO/IEC 21000-23 conforming smart contract will be able to know exactly what its clauses express.

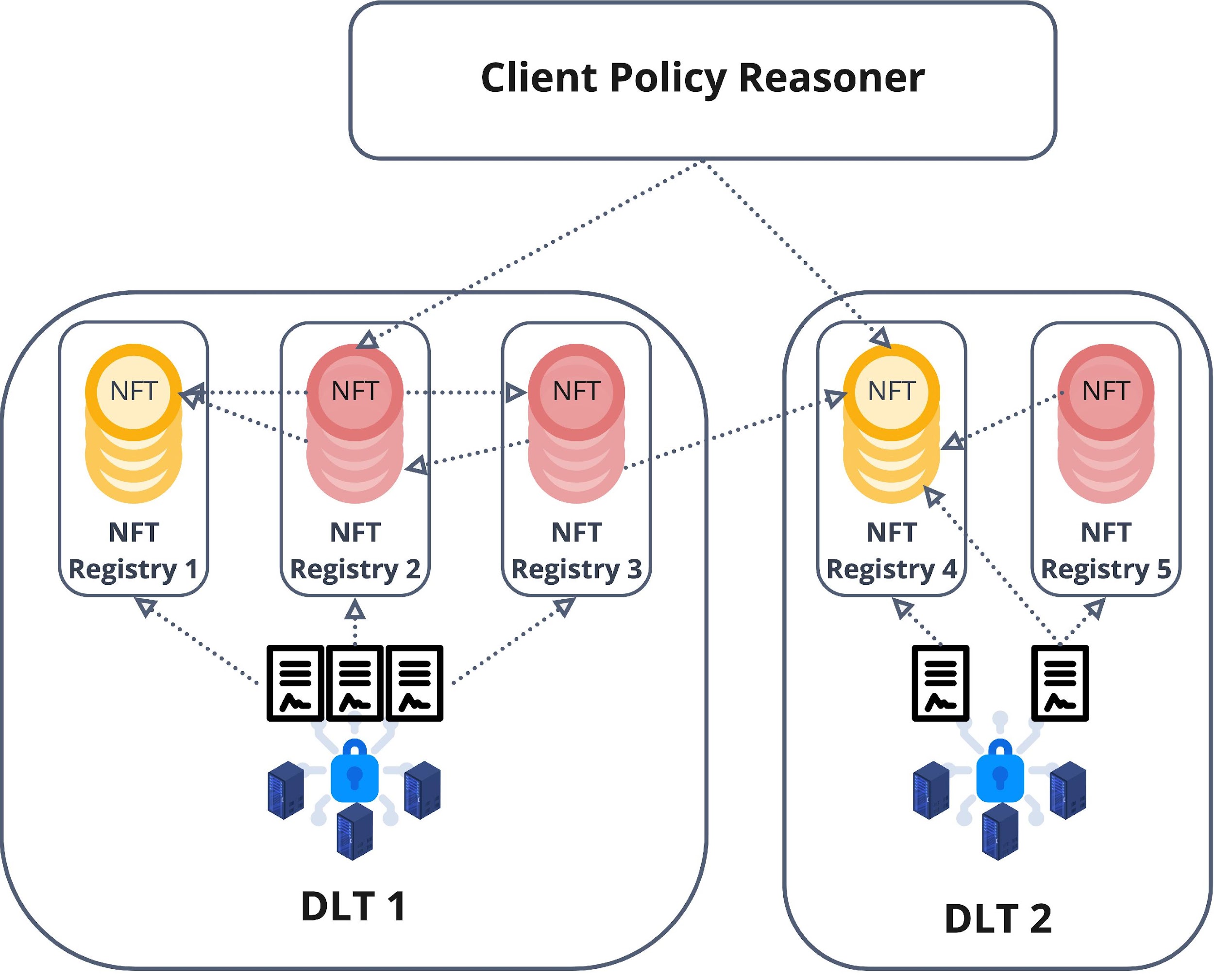
## The Non-Fungible Token as an interoperability enabler over the Smart Contracts for Media

The token representation is information recorded on a DLT representing some form of right: ownership of an asset, access to a service, receipt of payment, etc. For instance, the fungible token is one of the most used specifications for creating second-layer cryptocurrencies. The NFT is a utility token usually implemented to represent and transact with (tangible or intangible) assets on DLTs, where every single token is different from the rest of the tokens, i.e., non fungible. More specifically, NFTs combine both concepts of (i) access rights to an underlying economic value (property), and (ii) permission to access someone else’s property or services or collective goods. The asset considered here can be of many forms: (i) physical property, e.g., houses or unique artwork, (ii) virtual collectibles, e.g., unique pictures or collectible cards, (iii) negative value assets, e.g., loans, burdens, and other responsibilities. In general, NFTs are distinguishable, and the ownership of each one is tracked separately.

One of the roles adopted by the ISO/IEC 21000-21 Smart Contract for Media implementation is to directly and passively enact what is “enactable” (i.e., enforceable) in a DLT, with reference to the clauses indicated in the original narrative media contract. The second role of the Smart Contract for Media is to crystallize the data encoded using the Media Contractual Object. This is due to the native immutability feature that the DLTs’ ledger generally provides. Thus, once the Smart Contract for Media enters into action, i.e., it is deployed to the DLT, each piece of information related to the original contract can be validated against the stored Smart Contract for Media data, e.g., the address of a party or the fingerprint of a digital media. Each Media Contractual Object is then stored in the Smart Contract for Media. In particular, each IP Entity and Deontic Expression is stored in a unique NFT, while the rest of the objects are stored in the Smart Contract for Media using an ad-hoc data structure, e.g., a hash map. To be noted is also the fact that the MPEG-21 Contract object preamble might include the narrative contract text version, too, in the form of an object or at clause level, making thus explicit the legal isomorphism. NFTs are already used for encoding unique works resulting from human creativity and innovation, i.e., what intellectual property rights generally protect, that is the case of an IP Entity. However, what is not generally trivial is the use of NFTs to encode information related to the ownership of certain rights, such as permissions, obligations, and prohibitions.

Thanks to the Deontic Expression object representation, we can create referable rights and duties and save the association between this reference and the relevant party directly in the ledger in an immutable way through NFTs.

### **Non Fungible Tokens for linking policies and assets**

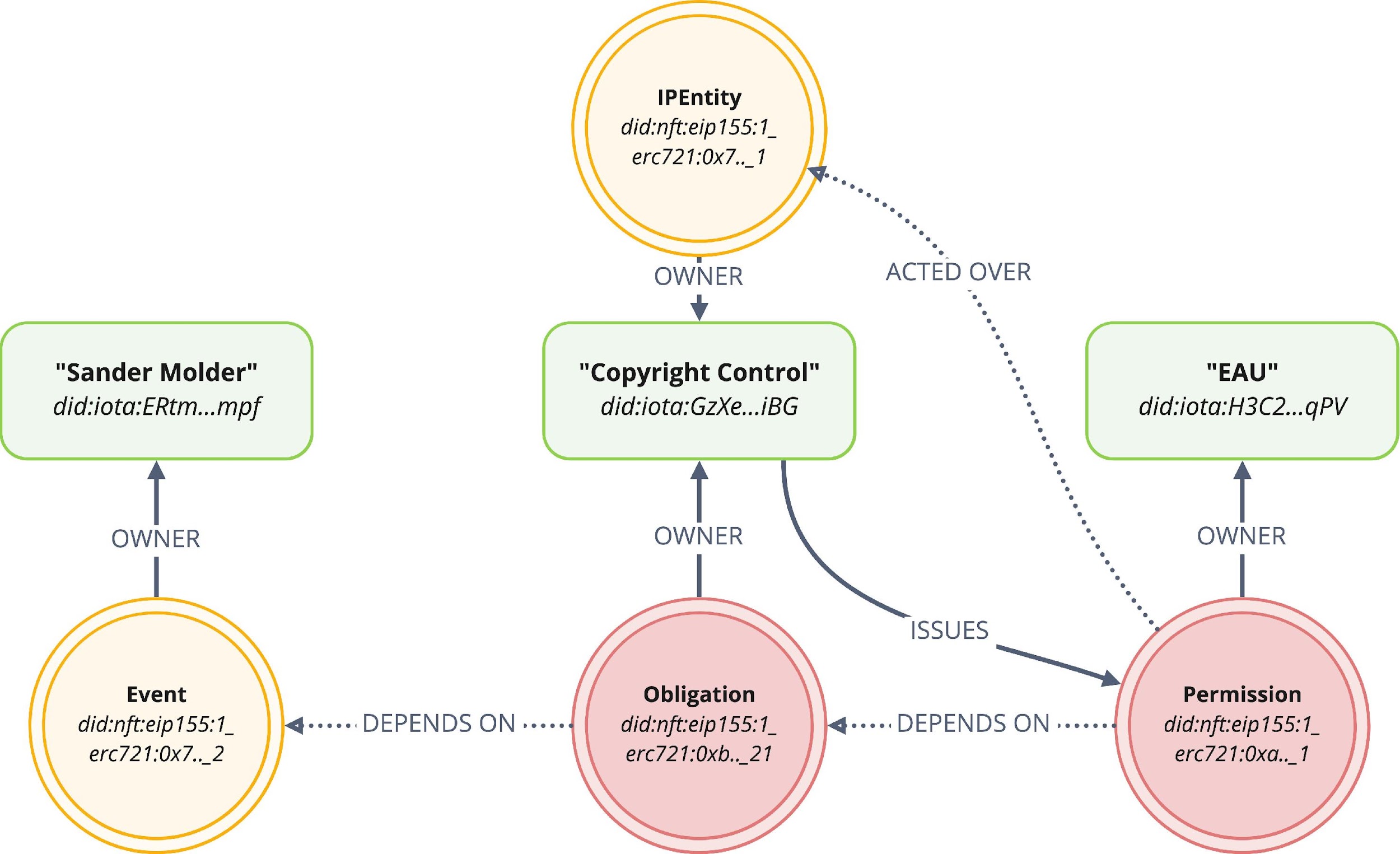


**Figure 4**: Diagram representing different NFT registries deployed in different DLTs with dependencies.

Consider a Policy Object as an encoding of some Deontic Expressions with reference to existent assets. By storing on-chain a cryptographic proof of the Policy Object, e.g., hash digest, and the actual Policy Object information off-chain (i.e., in a Decentralized File Storage, DFS, such as IPFS) allows us to maintain the verifiability property even if the access to the information is not public. Indeed, each Policy Object is stored in documents that can be maintained private, while their hash, and thus their immutability verification, can be made public. An NFT is used to store on-chain the hash pointer to retrieve the policy from the DFS. Thus, anyone with access to the DFS object can verify if it has been altered, and, at the same time, the content is not shared publicly with anyone without access.

There can be many *NFT registries*, i.e., smart contracts containing a registry for enumerating NFTs:

* such a registry contains a list of NFTs uniquely identifying a Policy Object or IP Entity object;
* in particular, the registry maps the NFT alphanumeric id to the DLT address of the *NFT owner*. The NFT owner is a Party, e.g., the Creator, that can decide to transfer or burn the NFT;
* the *NFT registry owner* is the party that gives the authorization to mint, i.e., create, a new NFT in that registry;
* when a new NFT is created, the NFT registry smart contracts bind the NFT owner to the NFT alphanumeric id and then set the NFT metadata as the hash pointer to the Policy Object.



**Figure 5:** Diagram representing NFTs and the dependencies among the metadata (i.e., Deontic Expressions and IPEntities) they include.

An example is shown in Figure 5. In that Figure, red circles are NFTs representing Deontic Expression objects, yellow ones represent IP Entity objects (Event is a type of IP Entity), and the actors are displayed in green boxes. The relations shown through arrows are encoded using the combination of MPEG-21 MCO and MVCO properties in the corresponding Policy Object. The Figure shows a scenario in which a subject *did:nft:eip155:1\_erc721:0x71C7656EC7ab88b098defB751B7401B5f6d8976F\_2* (i.e., Creator Sander Molder) provides the license to a Distributor *did:iota:GzXeqBXGCbuebiFtKo4JDNo6CmYmGbqxyh2fDVKadiBG* (i.e., Copyright Control) through an Event NFT. This license is subject to an Obligation for the Copyright Control to pay 50% to song writers by minting some NFTs in one or more owned registries. Generally, this Figure shows an IPEntity, i.e., the Summer Jam song, the above-mentioned Obligation and a Permission to act over the IPEntity. In turn, the Permission depends on the Obligation and the latter depends on the license Event. As we will see in detail in the following, the ownership of the NFTs representing these Policy Objects allows:

* a Collective, i.e., EAU, to demonstrate the permission to make copy (reproduction) of the song;
* the Distributor, i.e., Copyright Control, to demonstrate the ability to provide the Permission to make copy to the Collective on the basis of the Obligation to pay 50% to song writer;
* the Creator, i.e., Sander Molder, to control the license, i.e., as the NFT can be burned to revoke the Obligation and thus the Permission.

This is one of the many possible scenarios, and different policies involving obligations or other bases for distribution can be encoded in other scenarios. Finally, using a single structure representation on-chain, i.e., the NFT registry, enables smart contract-level interoperability. For instance, different Distributors can have their registry smart contract, or there can be a single registry open for more Distributors and Collectives. At the same time, smart contracts deployed for other purposes can reference NFTs in those registries to have a direct link on-chain.

### **From Policy Objects to Non Fungible Tokens**

We focus now on the process creation of NFTs, taking as reference the scenario seen up to now. Figure 6 shows an encoding of Deontic Expressions discussed above.

The process works as follows:

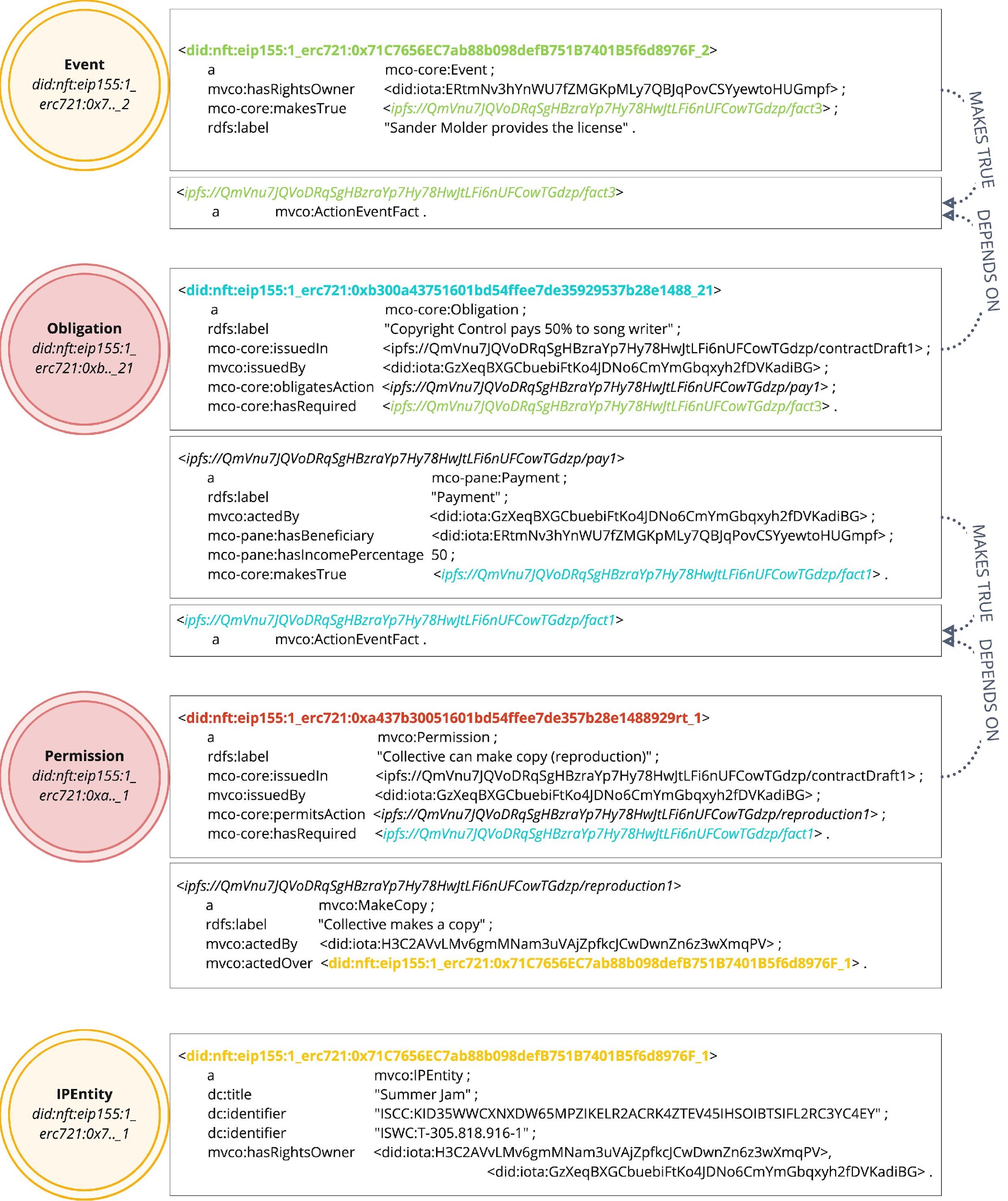
* On the basis of a contract as input, a set of Policy Objects is created.
* Each Policy Object is stored in a DFS, e.g., IPFS. For instance, for the Permission object in Figure 6, the RDF object associated with the predicate *mco-core:permitsAction* is a hash pointer when stored in the DFS, such as   
  *ipfs://QmVnu7JQVoDRqSgHBzraYp7Hy78HwJtLFi6nUFCowTGdzp/reproduction1*. This exact process has to be executed recursively for the nested RDF objects within this *ipfs://QmV...zp/reproduction1* object. At the end of this recursion, the Permission object *did:nft:eip155:1\_erc721:0xa437b30051601bd54ffee7de357b28e1488929rt\_1* is stored in a form like the one shown in Figure 6 next to the Permission rounded icon.
* The Smart Contract for Media forward conversion process directly interacts with an NFT registry smart contract for minting each Deontic Expression and IP Entity objects found in the set of Policy Objects, i.e., Media Contractual Objects. To maintain the immutability of information, the NFT metadata provided for minting is the hash pointer returned from the DFS. The NFT owners are indicated in the Policy Object, i.e., mvco:actedBy; how the DLT address is derived from an URI such as *did:iota:GzXeqBXGCbuebiFtKo4JDNo6CmYmGbqxyh2fDVKadiBG* is shown in the W3C DID standard as “DID Resolution”.
* The NFT registry smart contract returns the id of the NFT. Objects that do not have an on-chain representation, i.e., through an NFT, have their uri obtained from the storage where thei are located, e.g., *ipfs://QmV...zp/reproduction1.* Objects that do have an on-chain representation as an NFT have their URI in the following form: *did:nft:eip155:1\_erc721:0xb300a43751601bd54ffee7de35929537b28e1488\_2* where the *0xb300a43751601bd54ffee7de35929537b28e1488* would stand for the NFT registry smart contract address and *22* would be the id of the NFT within the registry. This notation follows the DID NFT method specification.

### **Reasoning over Non Fungible Tokens**

The reasoning of policies can be then based on a reference to one or many NFT registry smart contracts. The idea is that these registries, which include permissions, obligations, and prohibitions in the form of NFT, can be used to recreate the original CEL/MCO contract to reason over. The output of such a reasoning process is a boolean response. Starting again from the example in Figure 6, the Collective would need to receive the Permission from the Distributor in line with the Creator license Event. In order to make a copy, the Collective can provide the NFT’s id, i.e., *did:nft:eip155:1\_erc721:0xa437b30051601bd54ffee7de357b28e1488929rt\_1*, to demonstrate the permission to perform this action. This is valid only if this NFT “fits in the policy puzzle”. Indeed, full policy or CEL/MCO contract can be reconstructed based on the URIs found in the initial Permission and on the check for logical errors. In the above example, the reconstruction:n”.

* starts from the Permission *did:nft:eip155:1\_erc721:0xa437b30051601bd54ffee7de357b28e1488929rt\_1*;
* checks the required facts, i.e., the fact   
  *ipfs://QmVnu7JQVoDRqSgHBzraYp7Hy78HwJtLFi6nUFCowTGdzp/fact1,* by obtaining them from the DFS.
* the ActionEventFact *fact1* is associated with the Pay action in Obligation *did:nft:eip155:1\_erc721:0xb300a43751601bd54ffee7de35929537b28e1488\_21*; then this Obligation object is obtained from the registri indicated in its DID; the Obligation information is merged with the one already got (i.e., the Permission and the Fact).
* the Obligation is related to another fact that brings to the final NFT, i.e. the Event *did:nft:eip155:1\_erc721:0x71C7656EC7ab88b098defB751B7401B5f6d8976F\_2*, that represent the release of license event.

If all linked NFTs do not present contradictions, then the original permission is valid. Otherwise, a possible logical breaking point could be the Pay action object does not make true ActionEventFact *fact1* because the license Event does not exist anymore. This example can be easily generalized. Moreover, thanks to DLTs and the NFT representation, all the permission, obligations and prohibitions concessions can be traced up to fine-grained detail.



**Figure 6:** Representation of NFTs metadata. Each NFT represents a Deontic Expression or IPEntity and these are linked between themselves. Some Actions or Events make true a Fact on which some Deontic Expressions depend (i.e., a Fact must be true for a Deontic Expressions to be valid).

# Marketplace

The marketplace within the Decentralized Media Rights Application Format provides a space where creators can showcase their media assets, such as music, videos, images, or written content, to potential users, distributors, or licensing partners. It offers a platform for creators to present their work, including relevant information such as descriptions, previews, licensing terms, and pricing details. This allows interested parties to explore and evaluate the media assets available for licensing or acquisition. One of the key features of the marketplace is its decentralized nature, which reduces the need for intermediaries, such as traditional publishing houses or content distributors.

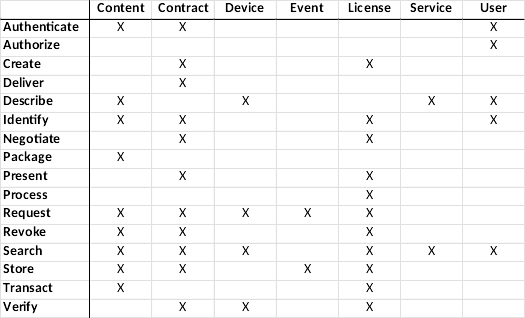
Within the marketplace, creators can set their own licensing terms, including pricing structures and usage rights, allowing them to retain greater control over their intellectual property. Licensing agreements can be negotiated and finalized directly between creators and potential licensees, ensuring a fair and transparent process.

* A “License Template”, e.g., Smart Contract for Media, is created by a User and sets a product’s licensing availability. It defines available permissions, prohibitions, and obligations related to one or more media assets (i.e., as a single product, a series, etc.).
* A “Custom License” is created by a User by filtering and selecting all terms and conditions included in a License Template.
* A “User” can have various roles: creator, rightsholder, distributor, consumer, etc.
* A “Seller” is a User who owns content to be placed into the marketplace,
* A “Buyer” is a User who has ability to (i) browse the marketplace (typically online via a browser); (ii) purchase content either for their own consumption or for further distribution as part of the Buyer’s service (e.g., the Buyer is an operator for OTT/web distribution, etc.); (iii) customize the Seller’s original License Template, so creating a Custom License.

## Relations to MPEG standards

Ed note: This section is tentative and needs to be revised

The entities described above can be placed in the context of the MPEG-M standards. The following tables describe the relations between action, entities, data formats.



**Table 4**: Actions and entities of commercial media trading in the marketplace according to MPEG-M

The entities can act in different ways with reference to the scope of the MPEG-M, as shown in Tables 4 and 5.



**Table 5**: Actions, entities, and data formats of commercial media trading in the marketplace

## Marketplace Scenario

1. A seller draws up the License Template (with no dependencies) and can subsequently edit or delete items of the Template using their authorized access to the seller area of a marketplace via the seller web interface.
2. A buyer uses a buyer web interface to select appropriate categories and clauses as allowed by the License Template to create the Custom License which resembles a physical license contract.
3. The Custom License is purchased and registered on an existing DLT environment. The contractual information is not editable or able to be deleted, even if its License Template is modified or deleted.
4. The written licensing agreement is generated and sent to the distributor with the selected purchased clauses. This then allows access to the content.
5. Distribution of the content is dependent on the chosen rights.

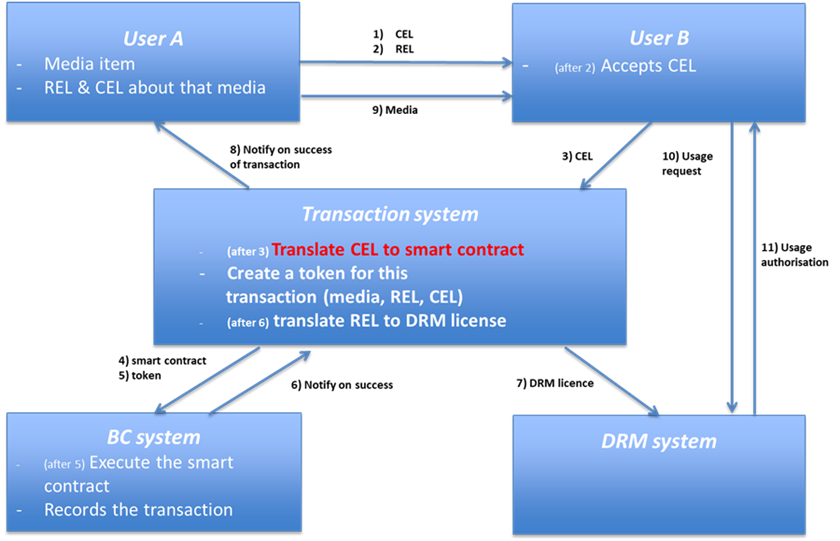
# Streaming and Playing

Within the Decentralized Media Rights Application Format, streaming and playing are essential components of the user experience, ensuring that media assets can be easily and seamlessly accessed by consumers. The Decentralized Media Rights Application Format may integrate with existing streaming platforms or support the development of decentralized streaming solutions, enabling users to securely access and enjoy licensed media content. To ensure fair compensation for creators, the Decentralized Media Rights Application Format may incorporate mechanisms for frictionless payments or micro-transactions during the streaming or playing process. This enables users to contribute directly to the creators by utilizing digital wallets, tokens, or other forms of decentralized payment systems. Such mechanisms ensure that creators receive appropriate remuneration based on consumption metrics, such as views, playtime, or user engagement.

Elacity (based on the Elastos ecosystem) is an example that uses MPEG Smart Contracts for Media (ISO/IEC 21000-23) specification and reference software in content transactions within blockchain systems. It implements a DASH video streaming player. Elacity is now a decentralized system for managing digital assets, such as media and intellectual property, using blockchain-based smart contracts. It facilitates the issuance, transfer, and monetization of these assets and enforces rights and royalties for stakeholders. The system includes modules for managing licenses, payments, and trades/transfers of assets, ensuring a secure and efficient ecosystem. The platform's smart contracts provide comprehensive solutions for various use cases, while the Authority Gateway ensures proper enforcement of payments and access. The License and Playback modules manage license acquisition and media asset playback using a DRM system. Elacity additionally leverages a novel cryptographic protocol using Webassembly to enable a user to fetch a licence key directly from the blockchain in a sandboxed environment with APIs for enterprises to provide a secure and decentralized ecosystem for managing digital assets. Elacity offers a secure and decentralized method for managing digital assets through blockchain technology.

## Streaming and Playing Scenario

In this scenario, it is proposed to use MPEG-21 CEL (together with MCO and MVCO) to express contracts that enable the content transactions between users and translate the CEL contracts into smart contracts for execution and transaction recording. It is also proposed to use the REL (or the rights languages in Widevine and Fairplay) to express usage rights of the transacted media item within the contracts and translate the REL expressions into the licenses of the existing DRM systems for rights enforcement and content protection of the media item.



**Figure 7**: Workflow for the content transaction scenario

Specifically, User A has a media item that User B wants to use. In order to transact the item to User B and allow consumption of the item, a Blockchain System and a DRM System need to be in place, together with a Transaction System that integrates them.

1. User A (e.g., distributor)

* Owns a media item, together with a REL license governing how the media item can used
* Possesses a CEL contract for transacting the media item with other Users for, e.g., changing ownership under certain compensation
* Associates the CEL contract to the media item and REL license
* Sends the CEL contract to User B

1. User B (e.g., consumer)

* Wants to use the media item (according to the REL license) associated in the CEL contract
* Accepts the terms in the CEL contract for transacting the media item
* Asks Transaction System to transact the item according to the CEL contract with User A

1. Transaction System

* Creates a blockchain token comprising a reference to the media item and the REL license
* Translates the CEL contract into a smart contract (code) for the target Blockchain System
* Sends the smart contract and the token to the Blockchain system for transaction and recording

1. Blockchain System

* Executes the smart contract on the Virtual Machine
* Records the output on the Blockchain System
* If the transaction requested by User B is permitted by the smart contract, then the Blockchain System
  + Checks for the amount to be paid
  + Requests B to pay
  + If payment is successful,
    - Authorises B to execute the transaction requested
    - Records the transaction

1. Transaction System

* Upon the transaction success from the Blockchain System,
  + receives information of User B’s DRM system,
  + translates the REL license into a DRM license of User B’s DRM system,
  + sends the media item and DRM license to the DRM system
* Notifies User B of the completion of the item transaction

1. User B

* Wants to use the media item
* Asks the DRM system to exercise the usage rights on the item

1. DRM System

* Delivers the media item to User B
* Authorizes the intended action on the media item, requested by User B, according to the DRM license

## File formats and streaming protocols

The following is a list of possible File formats and streaming protocols standards that are used in the Decentralized Media Rights Application Format.

* *ISO/IEC 14496-12 ISO Base Media File Format (ISOBMFF)* is currently the most widely adopted multimedia file structure standard (.mp4 extension) facilitating storage, interchange, management, and editing.
  + *ISO/IEC 23000-12 Interactive Music Application Format (IMAF)* is an ISOBMFF derived multimedia format, which specifies how to combine multiple audio tracks with additional information, e.g., dynamic volume changes for DJ mixing and lyrics for karaoke applications. For example, with IM AF various tracks can be remixed by users enabling them to share their remixes in social networks. Recipient users of the media can develop a reputation through music citations, similar to that of scientific citations.
  + *ISO/IEC 23000-19 Common Media Application Format (CMAF)* is an ISOBMFF derived multimedia format, which specifies segmented media objects optimized for streaming delivery and decoding on end user devices in adaptive multimedia presentations. Moreover, CMAF specifies sets of tracks that share encoding and packaging constraints that enable the selection of multiple tracks to form a multimedia presentation and allow seamless switching of alternative encodings of the same content at different bit rates, frame rates and resolution.
* *ISO/IEC 23009 Dynamic Adaptive Streaming over HTTP (DASH)* is an adaptive bitrate streaming technique, universally deployed, that allows smart TVs and mobile phones to consume high quality multimedia content, while seamlessly adapting to variable network conditions. Following the example of IM AF, DASH streaming enables radio producers and DJs to schedule playlists for streaming to their radio stations and clubs, respectively, and perform live mixing. In this case, artists could even be notified when their assets are scheduled for streaming, thus, enabling artists/fans interaction.

# References

[1] ‘Updated MPEG-21 template contracts in XML, RDF and JSON for the OMI use cases’, ISO/IEC JTC1/SC29/WG03/[N20314](https://dms.mpeg.expert/doc_end_user/documents/134_OnLine/wg11/MDS20314_WG03_N00252.zip), 134th MPEG Meeting, Apr. 2021.