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**MPEG Smart Contracts for Media**

In the last few years, MPEG has developed a set of standardized RDF ontologies and XML schemas for the codification of intellectual property (IP) rights information related to music and media. ISO/IEC 21000-19 Media Value Chain Ontology (MVCO) facilitates rights tracking for fair, timely, and transparent payment of royalties by capturing user roles and their permissible actions on a particular IP entity. ISO/IEC 21000-19/AMD1 Audio Value Chain Ontology (AVCO) extends MVCO functionality related to the description of IP entities in the audio domain, e.g., multitrack audio and time segments. ISO/IEC 21000-21 (2nd Ed) Media Contract Ontology (MCO) facilitates the conversion of narrative contracts to digital ones related to exploitation of IP rights, payments, and notifications. With respect to the latter, XML schemas have been developed as ISO/IEC 21000-20 (2nd Ed) Contract Expression Language (CEL).

Furthermore, the axioms in these XML schemas and RDF ontologies can drive the execution of rights-related workflows in controlled environments, e.g., Distributed Ledger Technologies (DLTs), where transparency and interoperability are favored toward fair trade of music and media. Thus, the aim of ISO/IEC 21000-23 Smart Contracts for Media is to provide the means (e.g., application programming interfaces) for converting these XML and RDF media contracts to smart contracts that can be executed on existing DLT environments.

By doing this conversion in a standard way for several smart contract languages, MPEG-21 CEL/MCO schemas and ontologies will prevail as the interlingua for transferring verified contractual data from one DLT to another.

Another important feature of this standard is that it offers the possibility to bind the clauses of a smart contract with those of a narrative contract and vice versa. In this way, each party signing a smart contract knows exactly what the clauses stored in the smart contract express.

**BACKGROUND**

***MOTIVATION***

MPEG-21 CEL/MCO schemas and ontologies can be used by music and media value chain stakeholders to share and exchange, in an interoperable way, all metadata and contractual information connected to creative works, leading to transparent payment of royalties and reduced time spent searching for the right data. The latter is due to inference and reasoning capabilities inherently associated with ontologies. That is, knowledge and data can be derived by evidence and logic based on rich semantic copyright models expressed by MPEG-21 CEL/MCO schemas and ontologies. In this way, the data derived are unambiguously interpretable, facilitating efficient processing in business-to-consumer (B2C) and business-to-business (B2B) music and media value chains.

Furthermore, for contractual music and media asset trading, smart contracts can be used to encode the terms and conditions of a contract. They validate contractual agreements between stakeholders before a DLT value transfer is enabled. In other words, smart contracts could allow music and media royalties to be administered almost instantaneously and manage usage allowances and restrictions. Rather than passing through intermediaries, revenue from a stream or download could be distributed automatically to rights holders, according to agreed terms and conditions (e.g., splits), as soon as an asset is downloaded or streamed.

However, the challenge that naturally arose was how MPEG-21 CEL/MCO standardized schemas and ontologies can be converted to smart contracts that can be executed on existing DLT environments, thus enriching DLT environments with inference and reasoning capabilities inherently associated with ontologies. Note that this process would increase trust among music and media value chain stakeholders for sharing data in the ecosystem since the data will be cryptographically secured and verified by a DLT [1].

By addressing this challenge in a standard and agnostic way, with respect to smart contract languages and thus DLT environments, MPEG-21 CEL/MCO schemas and ontologies will prevail as the interlingua for transferring verified contractual data from one DLT to another.

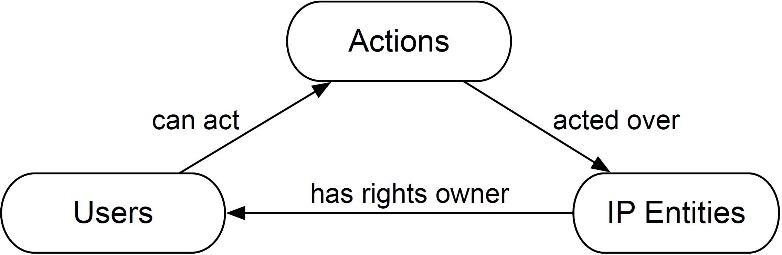
**TECHNOLOGY**

***THE MEDIA VALUE CHAIN ONTOLOGY***

The MVCO [2] formalizes the media value chain through three main entities: *IP entities*, as they are trans­formed along their life cycle, relevant *actions* that can be performed on such entities, and types of *users* whose actions are rights, obligations, and prohibitions.

IP entities are objects (e.g., work, manifestation, instance, product) in the media value chain, subject to protection by copyright law. The very first entity in the chain is the abstract creation, the *work*, which is the result of any intel­lectual endeavor with enough creativity. Works are pure, abstract entities with no material incarnation whatsoever. Deriv­ative works are special types of works derived from an existing work. Works are fixated into physical *manifestations*, which are the very first incarnation of works. Manifestations can be *instanced* and *copied*, or they can be transformed into commercial *products*.

A *user*, on the other hand,is an individual or organization acting on IP entities while undertaking different *roles*, e.g., creator, adaptor, producer, end user. The types of *actions* that can be performed by users are also revolve around the IP entities, e.g., create work, produce, public communication. Figure 1 illustrates these relationships among actions, users, and IP entities.



**Figure 1.** MVCO**-**defined relationships between actions, users, and IP entities.

The MVCO, by defining the relation­ships between users, actions, and IP entities, serves well to depict a static pic­ture of the IP information. However, in real life, rights are transferable, and this dynamic nature of rights is also supported by MVCO.

The transfer of rights is authorized by signatures on agreements or contracts that grant *permissions.* A permission relates an IP entity to a right in transit between the original rights owner and the new rights owner. Thus, permissions have an intrinsic dynamic nature: they are granted, invoked, and revoked.

Permissions can also be granted con­ditionally, that is, subject to certain conditions (*facts*). The evalu­ation of conditions against a certain context would determine whether a per­mission would actually be granted or not. In such a context, permissions can also be expressed as prohibitions (nega­tion of a permission) and obligations (the prohibition of not doing something).

Finally, the MVCO supports to some extent the so-called *copyright excep­tions*, a notion present in IP law to enable the reasonable use of copyrighted assets in certain cases.

***THE AUDIO VALUE CHAIN ONTOLOGY***

The AVCO facilitates transparent IP rights management for interactive music services (remixing, karaoke, and collaborative music creation) enabled by MPEG-A: Interactive Music Application Format [3], commercially known as *Stem* [4]. That is, AVCO extends MVCO functionality to address the issue of rights monitoring when reuse of audio IP entities is involved, such as tracks or even segments of tracks in new derivative works. To do so, AVCO introduces the following concepts: (i) *timeline:* a linear and coherent piece of time in relation to time-based IP entities, e.g., a vocal track can be associated with such a timeline; (ii) *interval*: a temporal entity defined by a start and end points on a given timeline, e.g., the chorus interval of a vocal track;(iii) *segment*: a slice of an IP entity with boundaries defined by the interval’s start and end points, e.g., the chorus interval’s IP entity; (iv) *track*: a single track of a multitrack audio IP entity, e.g., the vocal track’s IP entity. Through these concepts and the definition of a series of ontological classes and relationships, AVCO facilitates the description of composite IP entities in the audio domain, whereby the components of a given IP entity can be located in time and, with specific tracks.

***THE MEDIA CONTRACT ONTOLOGY***

The MCO [5] facilitates the conversion of narrative contracts to digital ones and permits the creation of new contracts in machine-readable electronic formats. It consists of a core model and two extensions. The core model, as shown in Figure 2, builds on top of MVCO generic deontic statements (e.g., permis­sion, prohibition, and obligation) by providing the elements for modeling the basic structure of media contracts (e.g., contract and parties’ identification and relationships with other contracts)*.* In the following, the two extensions are briefly described.

Diagram

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**Figure 2.** Themain elements of the MCO model.

1. *Exploitation of Intellectual Property Rights:* this extension provides the means to express the rights, typical used among audio-visual production companies and broadcasters, for media exploitation (e.g., public performance, communication to the public). These exploitation rights might also be associatedwith a wide set of *conditions* (*facts*; e.g., time periods, territories, exclusivity, roy­alty percentages), *modalities* (e.g., broadcast, broadband) and *access policies* (e.g., free of charge, subscription, pay per view). Complex rights’ dependencies can also be defined, such as, for instance, in the so-called catch-up TV service offered by several broadcasters.
2. *Payments and Notifications:* this extension provides the means to define specific obligations for completing a media contract scenario. Both payments and notifications are typically obligated actions that can either be triggered by rights exploitation actions or required as a precondition to rights exploitation actions.

Further information on MPEG-21 CEL/MCO ontologies and schemas can be found in [1] and in the related ISO/IEC 21000-19, 21000-19/AMD1, 21000-20 and 21000-21 standards mentioned in section “Resources”.

***RELATIONSHIPS BETWEEN MPEG-21 CEL/MCO AND DLTs***

This section describes the relationships between MPEG-21 CEL/MCO elements and DLTs components, for the conversion of MPEG-21 CEL/MCO contracts to smart contracts for media and vice versa.

1. *Contract - Smart contract for media*: the MPEG-21 CEL/MCO contract element is the one that includes or refers to the digitalized contractual information extracted from a narrative contract. Whilst the smart contract for media is the result of the conversion process from the MPEG-21 CEL/MCO contract. Thus, the counterpart of an instance of an MPEG-21 CEL/MCO contract is a unique smart contract for media deployed in a specific DLT.
2. *Party (user) - DLT address*: a party element is the representation of the identity of a user or organization bound by the narrative contract. Since identities in DLTs are represented through addresses, the party element counterpart is a DLT address. Thus, a party identity represented by a DLT address may also be authenticated in the DLT and referenced in a smart contract for media.
3. *IP entity - Non-fungible token*: an IP entity element 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 non-fungible tokens. Thus, in smart contracts an IP entity may be represented by a token. Then, the entire set of information related to a specific IP entity is linkable to the associated token.
4. *Deontic expression (action, fact) - Non-fungible token:* 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 serialized in accordance with the non-fungible tokens associated with the smart contracts for media.

*MPEG-21 CEL/MCO CONTRACTS TO/FROM SMART CONTRACTS CONVERSION*

The conversion between MPEG-21 CEL/MCO contracts to/from smart contracts for media is a bidirectional process involving several actors, software components and the DLT where a media smart contract would be (i.e., in the case of forward conversion) or has been (i.e., in the case of backward conversion) deployed.

*Forward conversion*

The forward conversion consists of a process that creates a smart contract for media from an MPEG-21 CEL/MCO contract. This process, which is shown in Figure 3, includes three software components. In the following, these components are briefly described.

Chart, diagram

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**Figure 3.** MPEG-21 CEL/MCO contracts to/from smart contracts conversion workflow.

1. *MPEG-21 CEL/MCO Parser:* a component that gets as input an MPEG-21 CEL/MCO contract and produces as output a set of media contractual objects. Media contractual objects is a structured set of information related to e.g., deontic expressions, actions, IP entities, and constraints, extracted from an MPEG-21 CEL/MCO contract. Media contractual objects are agnostic with respect to any specific DLT.
2. *Smart Contract Generator:* a component that gets as inputs, the result of the parser, i.e., a set of media contractual objects, and some DLT-specific smart contract templates, developed using a specific smart contract language, while produces as output a DLT-specific smart contract specification, i.e., a set of elements that represent the information needed to deploy the smart contract for media. Moreover, the smart contract specification includes information produced based on the objects found while traversing the set of media contractual objects, (e.g., royalties’ flow from obliged parties’ payments and non-fungible tokens from IP entities and deontic expressions).
3. *DLT Tokens and Payments Manager:* acomponent that gets as inputs a smart contract specification, a set of DLT addresses representing contract parties and a DLT governance protocol, i.e., the rules used by the DLT to update the ledger, while produces as output a DLT deployed smart contracts for media.

*Backward* *Conversion*

The backward conversion consists of a process that creates an MPEG-21 CEL/MCO contract from a smart contract for media deployed in a DLT. This process, which is also shown in Figure 3, includes two software components. In the following, these components are briefly described.

1. *Smart Contract Parser:* a component that gets as inputs a DLT deployed smart contract for media and a DLT-specific smart contract template, i.e., required for decoding the smart contract for media data structures, while produces as output a set of media contractual objects.
2. *MPEG-21 CEL/MCO Generator:* a component that gets as input a set of media contractual objects and produces as output an MPEG-21 CEL/MCO contract. That is, the MPEG-21 CEL/MCO generator is a component performing the backward operation with respect to the MPEG-21 CEL/MCO parser.

*NARRATIVE CONTRACTS*

In general, there is no way to deduce from a smart contract the clauses that the smart contract contains. Moreover, publishing the narrative contract does not ensure that the clauses of the narrative contract correspond to the clauses of the smart contract. There should be a way that allows the other party of the smart contract to know beyond doubt what the clauses stored in the smart contract express.

Thus, an important feature of smart contracts for media is that it offers the possibility to bind, through persistent links, the clauses of a smart contract to the corresponding ones of the narrative contract and vice versa, e.g., the narrative clause “user A pays $1 to user B” is bound to its counterpart smart contract clause “Transfer UserA UserB $1”. In the latter, if the beneficiary of the payment is not clear, the link to its corresponding narrative clause could be handy.

That is, the narrative version of a contract and its clauses represented by MPEG-21 CEL/MCO contracts are maintained all the way through the media contractual objects (textVersion and textClauses) to smart contracts and vice versa. In turn, this ensures the parties signing a smart contract to know beyond doubt what the clauses stored in the smart contract express with respect to the clauses of the narrative contract.

*REFERENCE SOFTWARE AND CONFORMANCE*

The API with respect to Figure 3 by facilitating the creation and handling of media contractual objects is fundamental for the bidirectional conversion from MPEG-21 CEL/MCO contracts to smart contracts for media. That is, this media contractual objects API is defined as normative. This API has been derived and shall be used in conjunction with MPEG-21 CEL/MCO ontologies and schemas mentioned in section “Resources”.

An implementation of the normative specified DLT agnostic media contractual objects API, as well as the required informative XML/Python and RDF/JavaScript reference software modules (e.g., parsers and generators) with detailed conformance testing instructions are provided for the bidirectional conversion of MPEG-21 CEL/MCO contracts to smart contracts for media. These software modules have been validated and demonstrated with pre-defined MPEG-21 CEL/MCO encoded contracts according to Open Music Initiative (OMI) [6] use cases (e.g., on-demand streaming and digital sale), as shown in Figure 4, and the following DLTs:

* MPEG-21 CEL contracts to Solidity/Ethereum and Michelson/Tezos smart contracts; and,
* MPEG-21 MCO contracts to Solidity/Ethereum and TEAL/Algorand smart contracts.

Timeline

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**Figure 4.** Selectable options provided by smart contracts for media reference software.

When the reference software instructions are followed it results in a demonstration where a user may select an MPEG-21 CEL/MCO contract from the several templates provided and a DLT to be deployed when converted to smart contract among those supported, as shown in Figure 4. Then, the user may parse the MPEG-21 CEL/MCO contract to create media contractual objects, generate the smart contract specification, and eventually deploy the resulted smart contract for media to the pre-selected DLT. The demonstration also includes graphical representations of the sharing revenues, e.g., splits, considered by the deontic expressions in the MPEG-21 CEL/MCO contracts. An online demonstration of the reference software, including videos explaining the bidirectional conversion process, can be found at: <https://scm.linkeddata.es/>

*CONCLUSIONS*

ISO/IEC 21000-23 Smart Contracts for Media standard specifies the means (e.g., application programming interfaces) for converting the MPEG-21 CEL/MCO ontologies and schemas to smart contracts that can be executed on existing DLT environments.

This important standard will greatly assist the music and media industry and its stakeholders in achieving effective interoperability for the exchange of verified contractual data between different DLT environments. 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 bind, through persistent links, 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.

**RESOURCES**

***Standards***

* ISO/IEC FDIS 21000-23, ‘[Information technology -- Multimedia framework (MPEG-21) -- Part 23: Smart Contracts for Media](https://www.iso.org/standard/82527.html)’, Jan. 2022.
* ISO/IEC 21000-19, ‘[Information technology -- Multimedia framework (MPEG-21) -- Part 19: Media value chain ontology](https://www.iso.org/standard/52887.html)’, June 2010.
* ISO/IEC 21000-8/AMD2, ‘[Information Technology -- Multimedia Framework (MPEG-21) -- Part 8: Reference software / AMD2 Reference software for media value chain ontology](https://www.iso.org/standard/57394.html)’, Nov. 2011.
* ISO/IEC 21000-19:2010/AMD1, ‘[Information Technology -- Multimedia Framework (MPEG-21) -- Part 19: Media Value Chain Ontology / AMD 1 Extensions on Time-Segments and Multi-Track Audio](https://www.iso.org/standard/71978.html)’, June 2018.
* ISO/IEC 21000-8:2008/AMD4, ‘[Information Technology -- Multimedia Framework (MPEG-21) -- Part 8: Reference Software / AMD 4 Media Value Chain Ontology Extensions on Time-Segments and Multi-Track Audio](https://www.iso.org/standard/74432.html)’, Oct. 2018.
* ISO/IEC 21000-21 (2nd Ed.), ‘[Information technology -- Multimedia framework (MPEG-21) -- Part 21: Media Contract Ontology](https://www.iso.org/standard/69299.html)’, May 2017.
* ISO/IEC 21000-20 (2nd Ed.), ‘[Information technology -- Multimedia framework (MPEG-21) -- Part 20: Contract Expression Language](https://www.iso.org/standard/68926.html)’, Dec. 2016.

***Reference Software***

* **Smart Contracts for Media:** <https://standards.iso.org/iso-iec/21000/-23/ed-1/en/>
* **Media Value Chain Ontology:** <https://tinyurl.com/y6tsr9as>
* **Audio Value Chain Ontology:** <https://standards.iso.org/iso-iec/21000/-8/ed-2/en/amd/4>
* **Media Contract Ontology:** <https://standards.iso.org/iso-iec/21000/-21/ed-2>

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[6] Rethink Music. “Fair music: Transparency and payment flows in the music industry,” BerkleeICE, 2015. [Online]. Available: <http://www.rethink-music.com/research/fair-music-transparency-and-payment-flows-in-the-music-industry>