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**CODING OF MOVING PICTURES AND AUDIO**

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| **Title:** | **Background and use cases for MPEG-21 smart contracts** |
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**The Challenge: From MPEG Intellectual Property Rights Ontologies to Smart Contracts and Blockchains**

Moving Picture Experts Group (MPEG) is an ISO/IEC working group developing media coding standards. This includes a set of ontologies for the codification of intellectual property rights (IPR) information related to media. The 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. The Audio Value Chain Ontology (AVCO) extends MVCO functionality related to description of IP entities in the audio domain, e.g., multi-track audio and time-segments. The Media Contract Ontology (MCO) facilitates the conversion of narrative contracts to digital ones. Furthermore, the axioms in these ontologies can drive the execution of rights-related workflows in controlled environments, e.g. blockchains, where transparency and interoperability is favored towards fair trade of music and media. Thus, the aim of this article is to create awareness of the MPEG IPR ontologies developed in the last few years and the work that is currently taking place - addressing the challenge identified - towards their execution as smart contracts on blockchain environments.

# BACKGROUND

Copyright legislation has continuously evolved with the aim to support the media industry, in face of technology progress, so that fair revenues are returned to artists and rights holders, multi-territory licensing, timely payments, and overall more transparency are improved. US Music Modernisation Act [1] and EU Copyright Directive Reform [2] are examples of these trends. Meanwhile, several key artists and media companies have turned their hopes for resolving these issues to technology and in particular, towards blockchain [3][4].

Blockchain emerged in 2008 as the technology that underpins bitcoin. It operates as a shared ledger, which continuously records transactions or information. Its database structure, where there is a timestamp on each entry and information linking it to previous blocks, makes it not only transparent but exceptionally difficult to tamper with.

Initiatives investigating blockchain have been launched around the world. In the US, Open Music Initiative (OMI) [3] has been launched by Berklee Institute for Creative Entrepreneurship, harnessing the MIT Media Lab's expertise in decentralized platforms, whose mission is: to promote and advance the development of open source standards and innovation related to music, to help assure proper compensation for all creators, performers and rights holders of music. It should be noted that OMI focuses, understandably, on (i) new works rather than the vast legacy music catalogue, with the aim that the same principles can be applied to legacy music retrospectively; and, (ii) on achieving interoperability among infrastructures, databases and systems so to be accessed, shared and exchanged by all stakeholders.

In Europe, one of blockchain's evangelists is the Grammy award-winning UK singer, songwriter and producer Imogen Heap. She has launched a blockchain project, Mycelia [4]. Although still in its foundational stages, she intends it to be an entire ecosystem that utilises blockchain as a way to enact a complete shake up in the music industry. Mycelia's mission is to: (i) empower a fair, sustainable and vibrant music industry ecosystem involving all online music interaction services; (ii) unlock the huge potential for creators and their music related metadata so an entirely new commercial marketplace may flourish; (iii) ensure all involved are paid and acknowledged fully; (iv) set commercial, ethical and technical standards in order to exponentially increase innovation for the music services of the future; and (v) connect the dots with all those involved in this shift from our current outdated music industry models, exploring new technological solutions to enliven and positively impact the music ecosystem.

Such missions can feasible be accomplished thanks to MPEG IPR ontologies, which can be used by music and media value chain stakeholders to share and exchange all metadata and contractual information connected to creative works, in a standardised and therefore interoperable way, leading to transparent payment of royalties and reduced time spend 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 (true facts) and logic based on rich semantic copyright models expressed by MPEG IPR ontologies. In such way, the data derived are unambiguously interpretable facilitating efficient processing in B2C and B2B music and media value chains.

However, whilst enthusiasm is growing for blockchain, it is likely to be several years before we see it rolled out in a wide-scale, mainstream capacity. Blockchain enables value to be transferred over the Internet. 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 blockchain value transfer is enabled [5]. In other words, smart contracts, implemented via software, 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 between rights holders, according to agreed terms and conditions (e.g., splits), as soon as an asset is downloaded or streamed [6][7].

That is, while various smart contracts solutions abound, it is likely that the technology will really only take off once there is a clear consensus in business about which standards will prevail [8]. So the challenge that naturally arises, is: How MPEG IPR standardised ontologies can be converted to smart contracts being executable on existing blockchain environments, thus enriching blockchain environments with inference and reasoning capabilities inherently associated with ontologies, while increasing the trust level among music and media value chain stakeholders for sharing data in the ecosystem, since the data will be cryptographically secured and its truth is verified by a blockchain?

From the other side, while lots of research literature deals with ontologies’ semantic-level interoperability (linking different ontologies) and blockchains’ protocol-level interoperability (transferring verified data from one to another), the interoperability gap between them has not yet been sufficiently addressed [9]. Towards this direction, MPEG is not going to develop any blockchain based technology or any new language for smart contracts. However, in the last few years MPEG has developed MPEG IPR ontologies, which facilitate the conversion of narrative contracts to digital ones. Thus, MPEG aim is to further develop the means (e.g., protocols and application programming interfaces) for converting MPEG IPR ontologies to smart contracts being executable on existing blockchain environments. In that way, it is going to bridge the interoperability gap between MPEG IPR ontologies (and consequently the semantic web) and blockchains.

Last but not least, a standards-based fair and sustainable trade of music and media ecosystem is envisaged [10], based on widely deployed MPEG technologies (e.g., audio-visual codecs, file formats and streaming protocols) [11], including emerging MPEG IPR ontologies executed as smart contracts on blockchain environments.

# USE CASES

## *Open Music Initiative (on-demand streaming, digital sale and radio broadcast):* These use cases are about how the money flows back to song writers, artists, publishers and labels, when their music is web cast or streamed on interactive services, sold on the digital platforms and played on the radio. In particular, for interactive streams and digital sales, how the money flows depends 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 [3]. In Table 1, high level contracts are provided for each of the aforementioned use cases.

|  |  |  |
| --- | --- | --- |
| **On demand streaming** | **Digital sale** | **Radio Broadcast** |
|  |  |  |
| Contract  For all P, C, W, S  Party: Streaming Service Provider P  Party: Streaming Service Consumer C  Party: Digital Distributor D    Statement 1  Subject: D  Act: Provide  Object: “Performance of Song” S  Permission 1  Subject: P  Act: Provide  Recipient: C  Object: “On demand Streaming Service” of S  Permission 2  Subject: Consumer C  Act: Pay  Recipient: P  Object: Subscription Fee X of “On demand Streaming Service”    Permission 3  Pre-condition:  ActionStatus{Permission 2}: ActionDone  Subject: Consumer C  Act: Consume  Object: “On demand Streaming Service” of S  Obligation  Pre-condition:  ActionStatus{Permission 2}: ActionDone  Subject: P  Act: Pay  Recipient: D  Object: 10.5% \* $X | Contract  For all D, C, L, S, X  Party: Music Distributor D  Party: Music Consumer C  Party: Music Label L  Statement 1  Subject: L  Act: Provide  Object: “Performance of Song” S  Permission 1  Subject: D  Act: Provide  Recipient: C  Object: S  Permission 2  Subject: Consumer C  Act: Pay  Recipient: D  Object: Purchase Fee X for S    Permission 3  Pre-condition:  ActionStatus{Permission 2}: ActionDone  Subject: Consumer C  Act: Consume  Object: S  Obligation  Pre-condition:  ActionStatus{Permission 2}: ActionDone  Subject: D  Act: Pay  Recipient: L  Object: 95% \* $X | Contract  For all D, C, L, S, X  Party: Radio Broadcaster D  Party: Music Label L    Statement 1  Subject: L  Act: Provide  Object: “Performance of Song” S  Permission 1  Subject: P  Act: Provide  Object: S  Constraint: Region  Obligation  Subject: D  Act: Pay  Recipient: L  Object: 95% \* $X |

**Table 1 - Open Music Initiative use cases with high level contracts.**

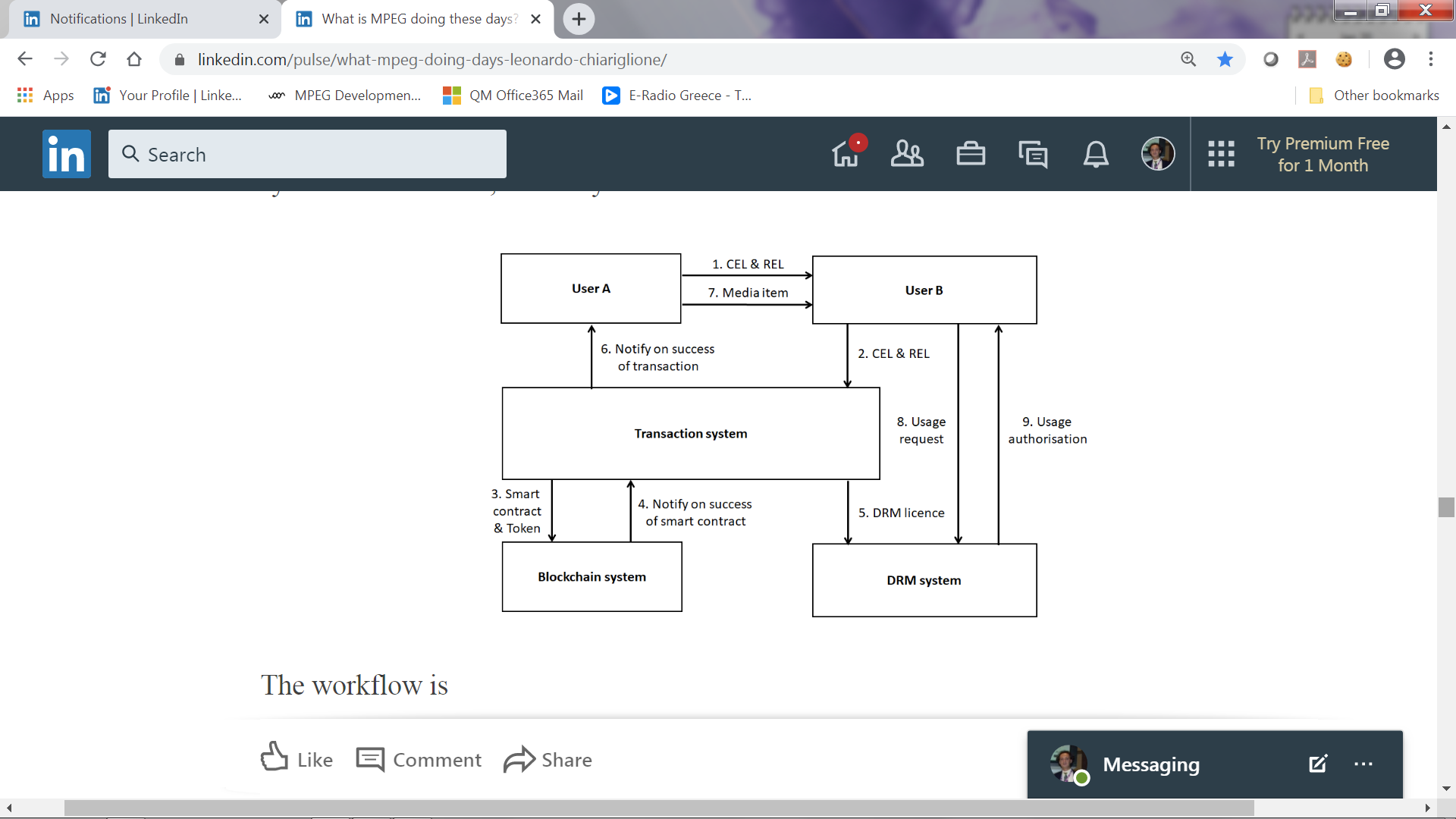
## Music authoring tools:Widespread adoption of interactive music services and applications (remixing, karaoke and collaborative music creation) - thanks to IM AF (ISO/IEC 23000-12) aka STEMS - raises the issue of intellectual property (IP) rights monitoring in such applications, for fair and transparent 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.

## *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 commonly used 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).

# WORKFLOW

MPEG has developed several standards in the framework of MPEG-21 media ecommerce framework addressing the issue of digital licences and contracts. Blockchain can execute smart contracts, but is it possible to translate an MPEG-21 contract to a smart contract?

Let’s consider the following use case where User A and B utilise a Transaction system that interfaces with a Blockchain system and a DRM system. If the transaction on the Blockchain system is successful, DRM System authorises User B to use the media item.



The workflow is

1. User A writes a CEL contract and a REL licence and sends both to User B
2. User B sends the CEL and the REL to a Transaction system
3. Transaction system translates CEL to smart contract, creates token and sends both to Blockchain system
4. Blockchain system executes smart contract, records transaction and notifies Transaction system of result
5. If notification is positive Blockchain system translates REL to native DRM licence and notifies User A
6. User A sends media item to User B
7. User B requests DRM system to use media item
8. DRM system authorises User B

In this use case, Users A and B can communicate using the standard CEL and REL languages, while Transaction system is tasked to interface with Blockchain system and DRM system.

A standard way to translate MPEG-21 contracts to smart contracts will ensure users that the smart contract executed by a blockchain corresponds to the human-readable MPEG-21 contract.

Those interested in exploring this topic can subscribe to the Ad hoc group on MPEG-21 Contracts to Smart Contracts at <https://lists.aau.at/mailman/listinfo/smart-contracts> and participate in the discussions at [smart-contracts@lists.aau.at](http://mailto:smart-contracts@lists.aau.at/).

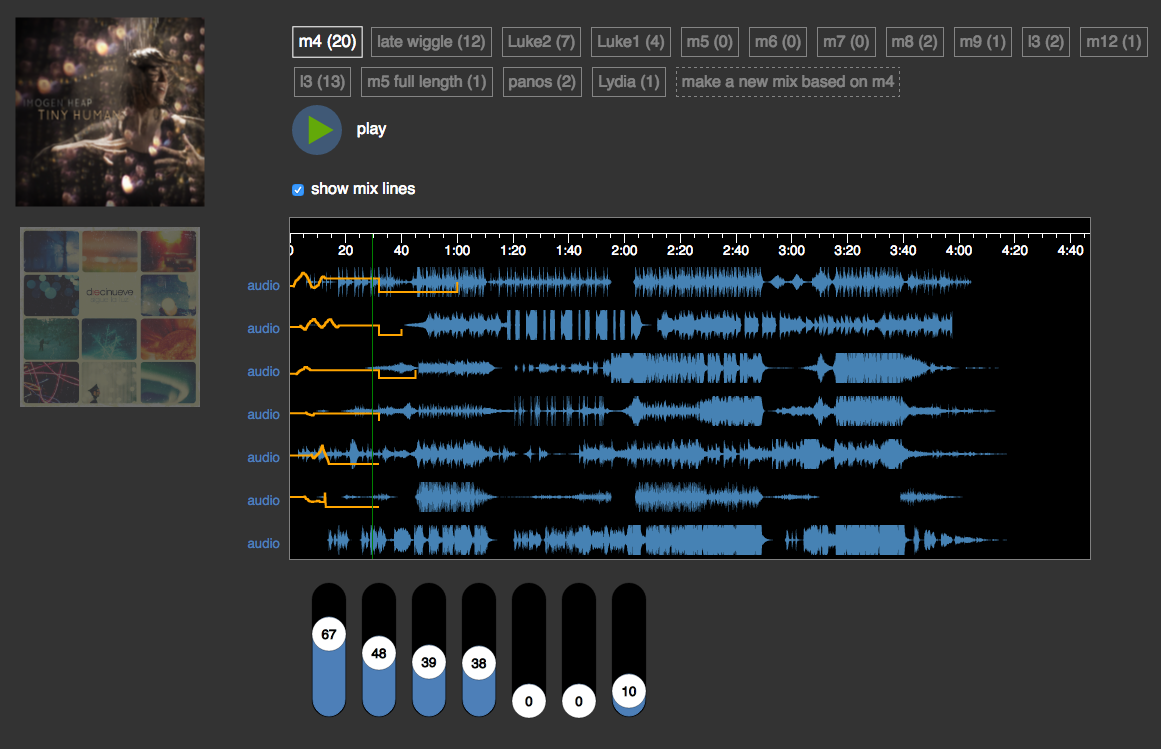
# API TO BE STANDARDISED & METHODOLOGY [18]

# RESOURCES

## Standards and Software

|  |  |  |  |
| --- | --- | --- | --- |
| **Acronym** | **Standard** | **MPEG Doc.** | **Ref. Soft.** |
| **MVCO** | 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. | [N11146](http://wg11.sc29.org/doc_end_user/documents/91_Kyoto/wg11/w11146.zip)  91st Kyoto | N/A |
| 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. | [N12135](http://wg11.sc29.org/doc_end_user/documents/97_Torino/wg11/w12135-v2-w12135.zip)  97th Torino | <https://tinyurl.com/y6tsr9as> |
| **AVCO** | 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. | [N17170](http://wg11.sc29.org/doc_end_user/documents/120_Macau/wg11/w17170.zip)  120th Macau | N/A |
| 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. | [N17404](http://wg11.sc29.org/doc_end_user/documents/121_Gwangju/wg11/w17404.zip)  121th Gwangju | <https://standards.iso.org/iso-iec/21000/-8/ed-2/en/amd/4> |
| **MCO** | 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. | [N15940](http://wg11.sc29.org/doc_end_user/documents/114_San%20Diego/wg11/w15940.zip)  114th San Diego | <https://standards.iso.org/iso-iec/21000/-21/ed-2> |
| **CEL** | 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. | [N15994](http://wg11.sc29.org/doc_end_user/documents/114_San%20Diego/wg11/w15994.zip)  114th San Diego | Included in N15994 |

## MixRights software for experimentation



**Fig. 1 - *Mixrights* application based on IM AF (ISO/IEC 23000-12).**

*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. The user can load IM AF files by simply dropping them on the browser window. Then, she can remove tracks, add new tracks by dropping audio files on the browser, add images and lyrics in the same way, or edit mix presets by playing the sequence and recording fader movements. Furthermore, *Mixrights* users can share their musical creations by uploading them to the server and sharing the links. Users can create new mixes of existing songs and instantly share them. *Mixrights* also keeps a count of the number of times a mix has been played. Mixrights software can be used for seamless integration with MPEG IPR ontologies based smart contracts for rights tracking towards fair payment of royalties. Those interested to work on this latter integration could get [*Mixrights*](http://mixrights.eecs.qmul.ac.uk/) software by contacting the author [of [M51376](http://wg11.sc29.org/doc_end_user/current_document.php?id=71633&id_meeting=180)].

## Content for experimentation

A song by Imogen Heap called ‘Tiny Human’ with all of its resources is made of, for experimentation purposes, can be found at: <http://imogenheap.com/home.php?article=2430>

* + Tiny Human
  + Tiny Human (instrumental)
  + Tiny Human (7 stereo stems)
  + Front cover image
  + The music video
  + Documentation about musicians, credits, lyrics, blockchain wallet address, and other useful info and links.

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**MPEG-21 Contracts to Smart Contracts Group Contributions**

* **Marrakech, 125th MPEG meeting**

**Output Documents**

[N18304](http://wg11.sc29.org/doc_end_user/current_document.php?id=66458&id_meeting=177) - MPEG 21 and blockchains

* **Geneva, 126th MPEG meeting**

**Input Documents**

[M47506](http://wg11.sc29.org/doc_end_user/current_document.php?id=67357&id_meeting=178) - On Implementing Content Transactions using MPEG-21 Technologies in Blockchains

**Output Documents**

[N18324](http://wg11.sc29.org/doc_end_user/current_document.php?id=67902&id_meeting=178) - AHGs Established at 127th Meeting

[N18537](http://wg11.sc29.org/doc_end_user/current_document.php?id=68100&id_meeting=178) - Use of MPEG-21 CEL in Blockchains

[N18500](http://wg11.sc29.org/doc_end_user/current_document.php?id=68064&id_meeting=178) - White paper on MPEG Intellectual Property Rights Ontologies

* **Gothenburg, 127th MPEG meeting**

**Input Documents**

[M49821](http://wg11.sc29.org/doc_end_user/current_document.php?id=69878&id_meeting=179) - AHG on MPEG-21 Contracts to Smart Contracts

[M49366](http://wg11.sc29.org/doc_end_user/current_document.php?id=69427&id_meeting=179) - On CEL for Smart Contracts

**Output Documents**

[N18543](http://wg11.sc29.org/doc_end_user/current_document.php?id=69969&id_meeting=179) - AHGs Established at 127th Meeting

* **Geneva, 128th MPEG meeting**

**Input Documents**

[M51211](http://wg11.sc29.org/doc_end_user/current_document.php?id=71468&id_meeting=180) - AHG on MPEG-21 Contracts to Smart Contracts

[M51376](http://wg11.sc29.org/doc_end_user/current_document.php?id=71633&id_meeting=180) - Some thoughts and resources on MPEG IPR ontologies based smart contracts

This contribution describes and clarifies ‘The Challenge: From MPEG IPR Ontologies to Smart Contracts and Blockchains’, that the AHG on ‘MPEG-21 Contracts to Smart Contracts’ is mandated to address. It also includes some resources (e.g., pointers to standards, content and software for experimentation) for the convenience of those interested in contributing to the activities of the AHG.

[M51030](http://wg11.sc29.org/doc_end_user/current_document.php?id=71287&id_meeting=180) - CEL Contract Templates for OMI Use Cases

This contribution analyses Open Music Initiative use cases (e.g., on-demand streaming, digital sale and radio broadcast) and provides high level contracts. That is, for interactive streams and digital sales, how the money flows depends 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.

[M51206](http://wg11.sc29.org/doc_end_user/current_document.php?id=71463&id_meeting=180) - The Tezos blockchain and its opportunities for media content tracking

This contribution briefly presents the ‘Tezos’ blockchain and the emerging opportunities for developing media-related decentralised applications. The main advantage of the ‘Tezos’ blockchain is its versatility, ensured by its properties, such as, reliability, upgrades, governance, self-amendment and proof-of-stake based consensus. Furthermore, ‘Tezos’ blockchain features four different smart contracts programming languages which can be interchanged. Thus, Tezos can serve as a testbed for the MPEG-21 smart contracts activity experimentations (as there is a need for independence wrt the platform). The weak point of ‘Tezos’ blockchain is related to the fact that its supporting community is yet rather small.

[M51208](http://wg11.sc29.org/doc_end_user/current_document.php?id=71465&id_meeting=180) - Tools for converting MPEG21-CEL to Tezos smart contracts

This contribution relates to the automatic, bidirectional conversion between XML (as a representation for CEL) and JSON. It presents software tools developed in both Csharp and Python, for achieving such a conversion. As an example, the automatic conversion of the CEL contract, which is part of the MPEG-21 CEL standard, is provided. Furthermore, this contribution demonstrates that the automatic conversion XML 🡨🡪 JSON is possible. However, this study is expected to be completed with automatic conversion between the JSON corresponding to a CEL contract and a ‘Tezos’ smart contract.

**Output Documents**

[N18750](http://wg11.sc29.org/doc_end_user/documents/128_Geneva/wg11/w18750.zip) - AHGs Established at 128th Meeting

[N18771](http://wg11.sc29.org/doc_end_user/documents/128_Geneva/wg11/w18771.zip) - Use cases for MPEG-21 smart contracts

This document approved by the Requirements group is based on the aforementioned contributions and, in particular, M51376 and M51030. Thus, presents the challenge the AHG is mandated to address, including use cases and related resources for further experimentation.

* **Brussels, 129th MPEG meeting**

**Input Documents**

[M52815](http://wg11.sc29.org/doc_end_user/documents/129_Brussels/wg11/m52815-v2-m52815.zip) - AHG on MPEG-21 Contracts to Smart Contracts

[M51587](http://wg11.sc29.org/doc_end_user/current_document.php?id=72029&id_meeting=181) - On the coupling of visual fingerprinting to blockchain

This contribution presents a technical solution ensuring the on-chain/off-chain load balancing of the tasks requiring computational/storage resources that exceed the current capabilities of blockchains. It allows for a straightforward coupling of the MPEG-21 CEL contracts to a blockchain, in the sense that the MPEG-21 CEL translation to smart contracts can be delegated from the on-chain to the off-chain blockchain processing and subsequently authenticated by the blockchain.

[M51588](http://wg11.sc29.org/doc_end_user/current_document.php?id=72030&id_meeting=181) - MPEG-21 CEL to TEZOS blockchain smart contracts conversion for visual content tracking

This contribution advances a processing-pipeline and establishes the PoC for the automatic conversion of the MPEG IPR ontologies based specific contracts (i.e., clauses in the MPEG-21 CEL sense) to blockchain smart contracts (with illustration for the liquidity language considered for the Tezos blockchain). It also identifies the scope of the current standardization efforts, namely an unique API (abstract class) allowing for different blockchain technologies to fetch data from MPEG IPR ontologies.

[M52742](http://wg11.sc29.org/doc_end_user/current_document.php?id=73184&id_meeting=181) - IPNG project: Blockchain solution for local authorities collaborative contractual signatures

This contribution reports on the IPNG project, a French national project related to a blockchain solution for local authorities collaborative contractual signatures.

**Output Documents**

N18974 - Background and use cases for MPEG-21 smart contracts

This document approved by the Requirements group is based on the aforementioned contributions and, in particular, M51376, M51030 and 51588. It presents the challenge the AHG is mandated to address, that is, converting MPEG IPR ontologies to smart contracts being executable on blockchain environments. It also includes related use cases (e.g., on-demand streaming, digital sale and radio broadcast), a walkthrough, the API identified for standardisation and related resources for further experimentation. It should be noted that for the conversion of MPEG IPR ontologies to smart contracts, the following methodology has been adopted: XML/RDF 🡨🡪 JSON 🡨🡪 Abstract Syntax Tree 🡨🡪 Smart Contract.