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The Challenge: From MPEG Intellectual Property Rights Ontologies to Smart Contracts and Blockchains

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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 a controlled environment, e.g. blockchains, where transparency and interoperability is favoured 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

MOTIVATION

Copyright legislation has continuously evolved with the aim to revive the music industry, in terms of fair and increased revenues returned to artists and rights holders, improved multi-territory licensing, timely payments, and overall more transparency, e.g., US Music Modernisation Act [1] and EU Copyright Directive Reform [2]. Meanwhile, several key artists and musicians 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 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 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 (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.

ISSUING BODY

MPEG officially known as ISO/IEC JTC1/SC29/WG11 is a Working Group (WG) of the Standardization Subcommittee (SC) 29 of the Joint Technical Committee (JTC) 1 of the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC), that develops and facilitates international standards within the field of audio, picture, multimedia, and hypermedia information coding.

In the last few years, a number of standardized ontologies have been developed by MPEG catering for the needs of the music and media industry with respect to codification of Intellectual Property Rights (IPR) information towards fair trade of music and media. These MPEG IPR ontologies have been developed, using World Wide Web Consortium's (W3C) Resource Description Framework (RDF), under the MPEG-21 Multimedia Framework (ISO/IEC 21000) family of standards, and include: Media Value Chain Ontology (ISO/IEC 21000 - Part 19), its extension with respect to multi-track audio and time-segments, known as Audio Value Chain Ontology (ISO/IEC 21000 - Part 19 / Amendment 1) and Media Contract Ontology (ISO/IEC 21000 - Part 21).

With respect to the latter an equivalent standard has also been developed using W3C's Extensible Markup Language (XML) known as Contract Expression Language (ISO/IEC 21000 - Part 20).

Next the aforementioned MPEG IPR ontologies are described.

TECHNOLOGY

MEDIA VALUE CHAIN ONTOLOGY

Main Entities

The Media Value Chain Ontology (MVCO) [12] is an ontology that formalizes the media value chain. The MVCO was designed to satisfy a number of requirements, which in turn, led to defining three entities of top importance: *intellectual property entities*, as they are transformed

along their life cycle, relevant *actions* that can be performed on them, and types of *users* whose actions are rights, obligations or otherwise foreseen by intellectual property law.

Intellectual Property (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 endeavour with enough creativity. Works are pure, abstract entities, with no material incarnation whatsoever. Derivative works are a special type of works, that have been 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*. Whereas the logical schema of IP entities resembles the Functional Requirements for Bibliographic Records (FRBR) chain [13], the source is somewhat different: MVCO catering for the needs of music and media stakeholders codifies the IP entities mentioned by copyright legislation (as defined by worldwide agreed treaties such as the Berne Convention), whereas FRBR is inspired by the needs of librarians.

A *user* is defined as an individual or organization, acting in the media value chain. The types of roles, a user could undertake, revolve around the IP entities, e.g., a creator is defined as the user who creates a work, an adaptor is the user who adapts a work to produce an adaptation. These roles or very similar ones are also acknowledged by copyright legislation. Other roles include producer, distributor and, finally the end-user.

The types of actions that can be performed also revolve around the IP entities. *Create work* is the action whose result is a new work, *produce* is the action whose result is a product and so forth. In addition, some other actions do not produce any new IP entity, such as, a public communication or an end-user action (e.g., play and print) but they are legal concepts with explicit mentions and provisions in copyright legislation.

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 performs 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, synchronise) that can be exercised on specific IP entities. Any given user may undertake any number of roles within a given value chain. Figure 1 illustrates these relationships between actions, users and IP entities.

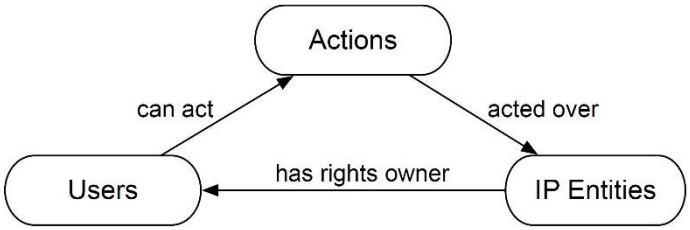

Fig. 1. MVCO defined relationships between actions, users and IP entities.

Authorisation Model

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 was required to be supported in the MVCO.

Transfer of rights are born with the signature of agreements or contracts which grant *permissions.* A permission relates an IP entity with a right in transit between the original rights owner and the new rights owner. Permissions have an intrinsic dynamic nature: they are granted, invoked and revoked. Instances of a *user* class will probably be actual companies or persons; instances of *works* will be actual works. However, instances of permissions are far more interesting due to that they could refer either to the past or in the future.

That is, an instance permission (e.g., Alice's permission to play a song) would be related to both: an end-user instance (e.g., Alice) and an action instance (e.g., play a song). However, what is the interpretation of an action instance? It might be an action effectively executed in the past (e.g., Alice played a song), but it might also be an action to be performed in the future, as a mere possibility (e.g., Alice can play a song). This is commonly referred in the literature as *event factuality*, and suggests that action instances can be marked as executed acts or as possible acts.

Permissions can also be granted conditionally, that is, subject to certain conditions (*facts*). Facts can be seen as propositions with an alethic (e.g., true or false) value. These propositions can be combined with logical operators (e.g., conjunction and disjunction) to create more complex conditions. 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. For example, complete quotes are allowed for scientific purposes, and parody is also permitted. The MVCO provides mechanisms for specifying such copyright exceptions, although the exceptions themselves are not specified.

AUDIO VALUE CHAIN ONTOLOGY

The Audio Value Chain Ontology (AVCO) facilitates transparent IP rights management even when content reuse is involved. In particular, widespread adoption of interactive music services (remixing, karaoke and collaborative music creation) enabled by MPEG-A: Interactive Music Application Format (IM AF) [14] (a.k.a. STEMS [15]), 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.

AVCO 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. In order to do so, AVCO introduces, as shown in Figure 2, the concepts of: a) *timeline* [16] which is 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; b) *interval* which is a temporal entity defined by a start and end points on a given timeline, e.g., the chorus interval of a vocal track; c) *segment* which is 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; and, d) *track* which is a single track of a multi-track audio IP entity, e.g., the vocal track's IP entity. 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.

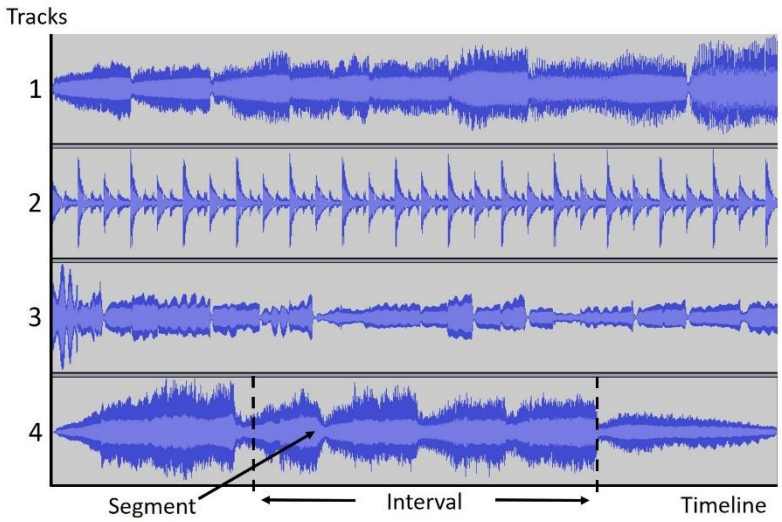

Fig. 2. Visualized multi-track audio. A segment exists within an interval on a timeline.

Relationships for IP entity segments and tracks

The AVCO defined classes and relationships are illustrated in Figure 3. Since IP entities in the audio domain constitute timed media, a timeline can be associated with them. That is, an IP entity through the property *interval* is linked to an interval (Interval class instance), which in turn, through the property *onTimeLine* is associated with a timeline. The property *interval* is also handy in order to be expressed that a segment exists within a specified interval on a timeline.

A segment is usually in a part-of relationship with an existing IP entity linked to it through the *hasSegment* property. However, a segment may also *contain* a different than the existing (reused) IP entity. In either case, since a segment is subsumed by the *IPEntity* class, it is an IP entity with its own value chain resolving to its rightsholders.

For the case of multi-track audio resources, an IP entity is related to a specific track with the *hasTrack* property. In order to be expressed that a segment exists on a certain track, it is linked to the respective track using the *onTrack* property.

In that way, reused IP entities may exist in specified segments of existing IP entities and, in the case of multi-track audio IP entities, on specified tracks.

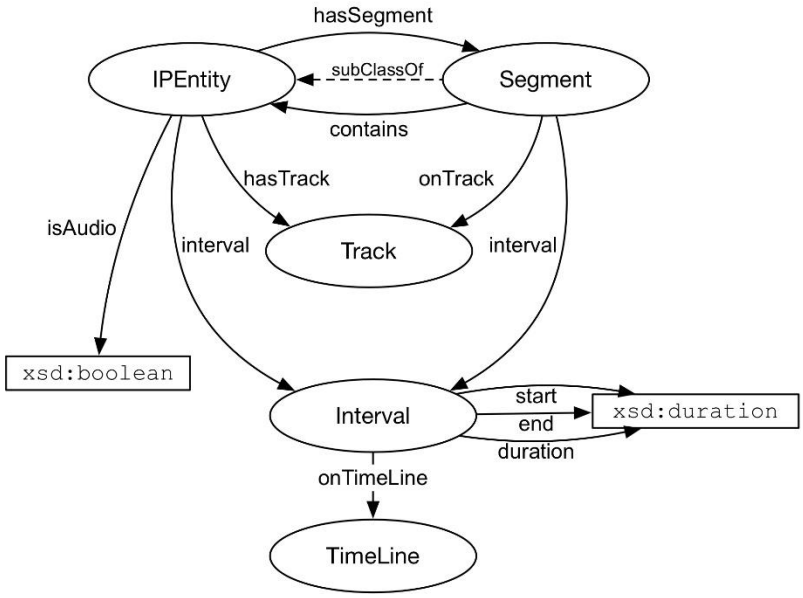

Fig. 3. ACVO defined classes and relationships for the representation of IP entities that contain other existing IP entities. Segments can also be associated with individual tracks of a multi-track audio IP entity.

MEDIA CONTRACT ONTOLOGY

The Media Contract Ontology (MCO) [17] facilitates the conversion of narrative contracts to digital ones and permits the creation of new contracts in machine-readable electronic format. It consists of a core model (mco-core) and two extensions. The core model, as shown in Figure 4, builds on top of MVCO generic deontic statements (encompassing the concepts of *permission*, *prohibition* and *obligation)* by providing the elements for modelling the basic structure of media contracts (e.g., contract and parties identification and relationships with other contracts). The two extensions are: i) Exploitation of Intellectual Property Rights; and, ii) Payments and Notifications.

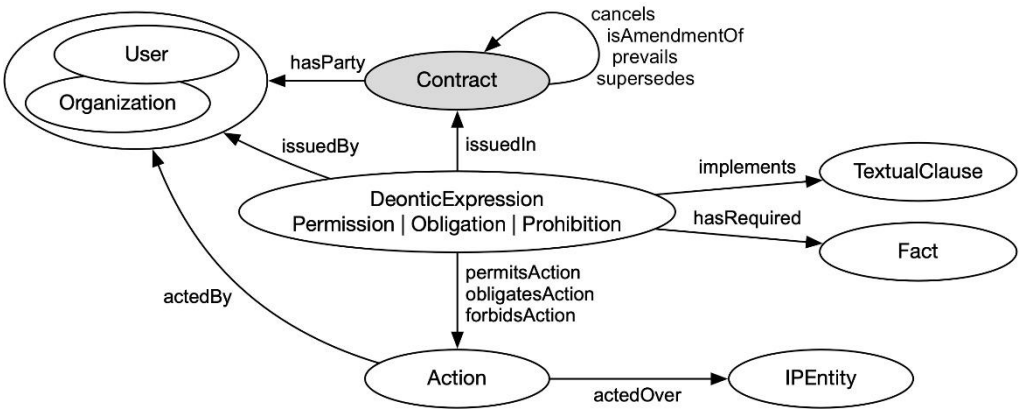

Fig. 4. Main elements of MCO model.

Exploitation of intellectual property rights

The extension for the exploitation of intellectual property rights (mco-ipre) 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 (*facts*) (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).

In the main model (mco-core), actions are permitted when the required conditions are met (e.g., the required *facts* are true). However, with this extension on exploitation of intellectual property rights (mco-ipre), dependencies between different actions can also be specified. That is, the occurrence of an action, for example the exploitation of a right, can trigger a condition for another action. This mechanism allows the specification of complex rights' dependencies, such as, for instance, in the so called catch-up TV service (a combination of both linear/broadcast and non-linear/broadband communication to the public) offered by a number of broadcasters. As an example, lets consider a broadcasting operator, who has acquired the right from a production company to *broadcast* a TV episode. The broadcasting operator has also acquired the right to make the TV episode available on-demand, from its web site to its subscribers via *broadband* access, but only after the TV episode has been broadcasted. In this

case, the latter right (communication to the public via broadband) is dependent upon the use of the former communication to the public via broadcast).

Payments and notifications

The extension for payments and notifications (mco-pane) provides means to define specific obligations, for completing a media contract scenario. Both payments and notifications are typically obligated actions which can either be triggered by (as a consequence of) or required as pre-condition to rights exploitation.

Eventually MCO can be used for the conversion of narrative media contracts to digital ones and vice versa. Such an MCO based rights management system has been build and used by Radiotelevisione Italiana (Rai) to store, access and modify information on media rights purchased and used across its departments involved from media production to broadcasting scheduling, improving media operations efficiency. Furthermore, inter-organisational (B2B) rights management interoperability could be achieved by the deployment of MCO open standards by other media production companies and broadcasting operators.

USAGE EXAMPLE

The MPEG IPR ontologies can be used as data models, e.g., knowledge graphs, for representing media rights. That is, actual users, media assets and rights can be represented in RDF, instantiating MCO/MVCO/AVCO classes. The next RDF statements declare a *work* identified by an International Standard Musical Work Code (ISWC) with exploitation rights assigned to a certain *PartyA*:

```
:myWork a mvco:Work;
      mvco:hasRightsOwner "PartyA";
      :myWork owl:sameAs "T-034.524.680-C";
```

The exploitation rights on this *work* may be described in a contract which is represented using MCO. A basic MCO contract follows. This allows the *communication to the public* right of the aforementioned *work* to be transferred from *PartyA* to *PartyB*:

```
:a Contract a mco-core:Contract;
      mco-core:hasParty "PartyA", "PartyB";
 [] a mvco:Permission ;
```

```
mvco:permitsAction mco-ipre:CommunicationToThePublic;
mco-core:issuedIn :aContract ;
mco-core:actedBy "PartyB";
```

In this usage example the joint use of terms defined in the *mvco* ontology (such as mvco:Permission), in *mco-core* (such as mco-core:Contract) and in *mco-ipre* (such as the communication to the public) has been shown. In practice contracts will contain a number of restrictions and obligations (such as payments).

FURTHER TECHNICAL DEVELOPMENTS

MPEG IPR ontologies 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 interoperable way, leading to transparent payment of royalties and reduced time spent searching for the right data.

Such MPEG IPR ontology standards should convince music and media industry stakeholders to accept technology developments catering for the needs of music and media rights transparency build upon open standards.

Furthermore, an MPEG ad hoc group, known as MPEG-21 Contracts to Smart Contracts has recently been established, with aim of addressing the aforementioned identified challenge. That is, this MPEG ad hoc group will investigate and develop hooks (e.g., protocols and application programming interfaces) for converting MPEG IPR ontologies to smart contracts being executable on existing blockchain environments, thus, further increasing the trust level among music and media value chain stakeholders for sharing data in the ecosystem. In that way, it is going to also bridge the interoperability gap between MPEG IPR ontologies (and consequently the semantic web) and blockchains. While the MPEG ad hoc group is at its infancy, it has attracted a significant number of industrial and academic experts from both the semantic and the blockchain communities, committed to work on the identified challenge. However, the current status of the work is at an exploratory phase and a publishable working draft is expected in the near future.

Last but not least, such developments towards a *semantic music and media blockchain* have the potential to unlock both the semantic web and the creative economy.

AUTHORS

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RESOURCES

Standards

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- ISO/IEC 21000-20 (2nd Ed.), 'Information technology -- Multimedia framework (MPEG-21) -- Part 20: Contract Expression Language', Dec. 2016.

Software

- **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
  Note: Source code files provided replace the corresponding MVCO ones.
- **Media Contract Ontology:** https://standards.iso.org/iso-iec/21000/-21/ed-2

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