Semantic Copyright Management of Media Fragments

Roberto García, David Castellà and Rosa Gil
Universitat de Lleida, Jaume II 69, Lleida, Spain

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Abstract: The amount of media in the Web poses many scalability issues and among them copyright management. This problem becomes even bigger when not just the copyright of pieces of content has to be considered, but also media fragments. Fragments and the management of their rights, beyond simple access control, are the centrepiece for media reuse. This can become an enormous market where copyright has to be managed through the whole value chain. To attain the required level of scalability, it is necessary to provide highly expressive rights representations that can be connected to media fragments. Ontologies provide enough expressive power and facilitate the implementation of copyright management solutions that can scale in such a scenario. The proposed Copyright Ontology is based on Semantic Web technologies, which facilitate implementations at the Web scale, can reuse existing recommendations for media fragments identifiers and interoperate with existing standards. To illustrate these benefits, the papers presents a use case where the ontology is used to enable copyright reasoning on top of DDEX data, the industry standard for information exchange along media value chains.

1 INTRODUCTION

Digitalisation and the transition to a Web full of media, where video already amounts more than half of online consumer traffic[1], have introduced new scalability requirements like bandwidth exigencies, which technology is rapidly evolving to cope with. However, there are other limiting factors that are not scaling so well, especially those that have been traditionally slow moving like copyright.

As the amount of content made available through the Web grows, for instance 72 hours of video are uploaded to YouTube every minute[2], the problem of managing its copyright becomes even more relevant. Consequently, there is already a need to make rights management scale to a web of media, as pointed by recent initiatives like the PLUS Coalition[3] or the Linked Content Coalition[4]. These initiatives, among other things, propose ways to represent and communicate rights so they can be automatically processed in a scalable way.

However, the issues associated with copyright management at a Web scale become even more complex when it goes beyond simple access control and takes into account also content reuse and the whole content value chain. In this case, rights representations need to be more sophisticated so they can capture the full copyright spectrum.

In addition, as reuse is easier when considering just fragments, spatial or temporal, of existing content and not full content pieces. Proposed solutions should scale not just to a Web of media but also to a Web of media fragments. Fragments, accompanied by scalable copyright management for the full value chain, enable a potentially enormous re-use market.

The main contribution described in this paper is a Web ontology for the representation and communication of rights and licensing terms over media assets in terms of their fragments. The ontology is based on Semantic Web technologies and integrates with the W3C Media Fragments Recommendation (Troncy et al., 2012) to define and describe spatial and temporal media fragments.

The ontology makes it possible to underpin the media discovery and usage negotiation process,

[1]Cisco's Visual Networking Index, http://www.cisco.com/en/US/netsol/ns827/networking_solutions_white_papers_list.html
[2]YouTube Statistics, http://www.youtube.com/yt/press/statistics.html
[3]PLUS Coalition, http://www.useplus.com
[4]Linked Content Coalition, http://www.linkedcontentcoalition.org

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facilitating the automation of functionalities for rights management. Based on an explicit and interoperable semantic representation for the communication of rights, the ontology facilitates assessing the reusability of a given media asset fragment and eases bringing content onto this flourishing market. For instance, by interoperating with DDEX data[5], one of the main standards for automating the exchange of information along the digital supply chain.

The rest of the papers is organised as follows. First, in Section 2, related work is presented together with the W3C Media Fragments recommendation that makes it possible to attach licenses to media fragments. Then, the Copyright Ontology is presented in Section 3 and a use case showing this ontology in practice is included in Section 4. Finally, Section 5 presents the conclusions and the future work.

2 RELATED WORK

The DRM Watch review on DRM standards (Rosenblatt, 2008) shows that interoperability is a key issue for DRM systems. For instance, it arises in the content distribution scenario when users want to consume content in any of the devices they own. Interoperability is also critical in the organisation scenario, when content flows through organisations or external content is used in order to derive new one.

The main response to DRM interoperability requirements has been the settlement of many standardisation efforts. The main ones are ISO/IEC MPEG-21 (Wang et al., 2005) and ODRL (Iannella 2002), and in both cases the main interoperability facilitation component is a Rights Expression Language (REL).

The REL is a XML Schema that defines the grammar of a license modelling language, so it is based on a syntax formalisation approach. There is also the MPEG-21 Rights Data Dictionary and a ODRL Data Dictionary Schema (DD) that captures the semantics of the terms employed in the REL, but it does so without defining formal semantics (García and Delgado, 2005).

This syntax-based approach is also common to other DRM interoperability efforts and one of main causes of the proliferation of interoperability initiatives that cannot interoperate among them, like in the e-books domain (Rosenblatt, 2009). Despite the great efforts in place, the complexity of the copyright domain makes it very difficult to produce and maintain implementations based on this approach.

The implementers must build them from specifications that just formalise the grammar of the language and force the interpretation and manual implementation of the underlying semantics. This has been feasible for less complex domains, for instance when implementing a MPEG-4 player from the corresponding specification. However, this is hardly affordable for a more complex and open domain like copyright, which also requires a great degree of flexibility.

Moreover, the limited expressivity of the technical solutions currently employed makes it very difficult to accommodate copyright law into DRM systems. Consequently, DRM standards tend to follow the traditional access control approach. They concentrate their efforts in the last copyright value chain step, content consumption, and provide limited support for the other steps.

In fact, just Internet publishing risks are considered and the response is to look for more restrictive and secure mechanism to avoid access control circumvention. This makes DRM even less flexible because it ties implementations to proprietary and closed hardware and software security mechanisms.

The limited support for copyright law is also a concern for users and has been criticised, for instance by the Electronic Frontier Foundation (Doctorow, 2005). The consequence of this lack is basically that DRM systems fail to accommodate rights reserved to the public under national copyright regimes (Springer and García, 2008).

Consequently, the DRM world remains apart from the underlying copyright legal framework. As it has been noted, this is a risk because DRM systems might then incur into confusing legal situations. Moreover, it is also a lost opportunity because, from our point of view, ignoring copyright law is also ignoring a mechanism to achieve interoperability. Therefore, DRM must evolve to Copyright Management.

It is true that copyright law diverges depending on local regimes but, as the World Intellectual Property Organisation[6] promotes, there is a common legal base and fruitful efforts towards a greater level of copyright law worldwide harmonisation.

A new approach is necessary if we want profit

[5]DDEX, http://www.ddex.net

[6]WIPO, World Intellectual Property Organization, http://www.wipo.int

from the Internet as a content sharing medium. The existence of this opportunity is clear when we observe the success of the Creative Commons initiative, whose objective is to promote content sharing and reuse thorough innovative copyright and licensing schemes.

However, despite the success of Creative Commons licenses, this initiative is not seen as an alternative to DRM. The main reason is the lack of flexibility of the available licensing terms. There are mainly six different Creative Commons licenses, all of them non-commercial, and just an informal mechanism for extension and adoption of alternative licensing schemes, CC+[7].

Moreover, Creative Commons licenses are available in three formats: a legal version for lawyers, a more readable version for average users and as metadata for computers consumption. However, the Creative Commons metadata is not a formal representation of the licenses; it just provides a reduced set of terms for building computer-oriented licenses. There are three kinds of permissions (reproduction, distribution and derivative works), one prohibition (commercial use) and four requirements (attribution, notice, share alike and source code).

Consequently, although it is possible to provide computer support for simple services like content search, there are no mechanisms for customisation and advanced computerised support that enable an Internet-wide copyright-based alternative to DRM systems.

2.1 Media Fragments

Media fragments are defined by spatial or temporal boundaries in media assets. For temporal boundaries, they are based on a start time point and an end time point (or a duration) that define a temporal subset of the original media. This kind of fragments can be also defined for audio content.

Spatial boundaries are specific to visual media (pictures or videos) and correspond to a subarea in the original media. The subarea is usually shaped as a rectangle defined by two points or one point plus a height and width. The point coordinates and the sizes are usually defined using pixels or percentages.

To make media fragments scale, its creation can be automated based on media analysis techniques capable of determining appropriate spatial and temporal boundaries in visual media, in which a self-contained part of the media can be found.

[7]http://wiki.creativecommons.org/CCPlus

Media analysis techniques can be also used to create semantic media fragment descriptions, which permit the connection of self-contained media fragments to the concepts (things, people, locations, events...) they are perceived as representing. Semantic descriptions can be also derived from existing metadata generated in the media production process and augmented by tools provided within the media creation phase.

Semantic technology is a means to describe media in a way that can be understood and processed by machines. Concepts can be unambiguously identified by URIs using Semantic Web Linked Data principles (Hausenblas et al., 2009). Ontologies, which define permitted terms and how they relate to one another, are the basis for machine reasoning and automatic derivation of new knowledge about the media (e.g. a fragment which shows Angela Merkel is also showing the German Chancellor).

The W3C Media Fragment URI specification serves as a media format independent, standardised means of addressing parts of media resources using URIs, for instance as shown in Table 1.

The use of the Media Fragment URIs provides a consistent identification of fragments in all stages of the media workflow as well as re-use of current tools and services which support the specification. Moreover, it becomes trivial to enrich media fragments descriptions with semantic data based on Semantic Web technologies, which use URIs as the way to identify resources.

For instance, the Copyright Ontology, described in the next section, makes use of fragment URIs and can attach to them information about their rights situations, licensing terms, etc.

Table 1: Media Fragment URI example.

http://my.tv/video.ogv#	**t=60,100&**	**xywh=12,12,42,30**
	Time fragment, from 60s. to 100s.	Spatial fragment, rectangle from pixel x=12, y=12 and width 42px, height 30px

3 THE COPYRIGHT ONTOLOGY

The Copyright Ontology has been engineered following the Methontology (Gómez-Pérez et al., 2004) methodology for ontology engineering. It provides guidance for ontology development process but also for other support and management activities. The ontology developing process it proposes is composed by the following phases: specification, conceptualisation, formalization, implementation and maintenance.

The specification phase corresponds to the pre-development aspects, where the development requirements are identified. The maintenance phase is a post-development activity, it is performed once the ontology is developed. During the conceptualisation activity, the domain knowledge is structured as meaningful models. The static part of the conceptualisation corresponds to the concepts called continuants or endurants (Gangemi, 2002). Then it is time to the dynamic part, which corresponds to the concepts called ocurrents or perdurants (Gangemi, 2002). The process is inspired by the way we actually model the dynamic aspects of the world using our main knowledge representation tools, i.e. natural language. The central piece is the verb, which models the dynamic aspects and constitutes the core of natural language sentences.

The objective is to apply this same pattern when modelling the dynamic aspects of an ontology. The first step is to identify the verb concepts corresponding to the ocurrents in the domain at hand, i.e. processes, situations, events, etc. These concepts will constitute the main part of the model for the dynamic part, just the same role verbs play in NL sentences.

This first step just identifies some concepts that are not enough to build complex knowledge expressions. In order to do that, the inspiration is also from how NL sentences work. In NL sentences, the verb is connected to other sentence constituents, i.e. participants, in order to build expressions that model processes, events, situations, etc. This kind of connection has been studied for long in the NL domain and a characterisation of them has been made. These connections are characterised as verb fillers called case roles or thematic roles (McRae et al., 1997).

This approach has been extensively used in the NL research domain but there is little work about applying case roles for knowledge representation. There is the FrameNet (Fillmore et al., 2003) initiative but it is mainly oriented towards knowledge acquisition from NL sources by semi-automatic annotation.

Two of the main proposals about the application of case roles for knowledge representation are those for Sowa (Sowa, 2004) and Dick (Dick, 1991). From these sources, a selection of case roles that can be extensively used to model the dynamic part of ontologies has been built. The contribution of this selection is that it is specially tailored to be integrated as a pattern for ontology engineering.

Table 2 shows this case roles selection, which is organised in four classes of generic case roles, which are shown at the top, and six categories, which are shown at the right. These categories correspond to verb semantic facets, not disjoint classes of verbs. Therefore, the same verb concept can present one or more of these facets. For instance, the play verb can show the action, temporal and spatial facets in a particular sentence.

Table 2: Case roles for the NL-oriented pattern.

	initiator	**resource**	**goal**	**essence**
Action	agent, effector	instrument	result, recipient	patient, theme
Process	agent, origin	matter	result, recipient	patient, theme
Transfer	agent, origin	instrument, medium	experiencer, recipient	theme
Spatial	origin	path	destination	location
Temporal	start	duration	completion	pointInTime
Ambient	reason	manner	aim, consequence	condition

Consequently, once the verb concepts have been identified, the second step of the proposed pattern corresponds to the process of determining the case roles that are necessary to build the dynamic model. Formal methods can be employed to constraint how the verb concept and the case roles are related. Therefore, this pattern allows a great range of model detail levels. Moreover, it is a very complete set of case roles. It includes all the case roles identified in the refereed bibliography and, as it is shown in the next subsection, it has been used during the Copyright Ontology development. During this development process no case role lack was detected and all the verb models could be built with just the case roles in Table 2.

3.1 Conceptualisation

This section details the Copyright Ontology conceptualisation activity. This activity is used as an illustrative example of the pattern presented in the previous section, which was employed in the Copyright Ontology engineering process.

The copyright domain is a complex one and conceptualising it is a very challenging task. The conceptualisation process, as it has been shown in the pattern description, is divided into two phases. The first one concentrates on the static aspects of the domain. The static aspects are divided into two different submodels due to its complexity.

First, there is the creation submodel. This model is the basis for building the conceptual models of the rest of the parts. It defines the different forms a creation can take, which are classified following the three main points of view as proposed by many upper ontologies, e.g. the Suggested Upper Merged Ontology (Niles and Pease 2001):

- **Abstract:** Work.
- **Object:** Manifestation, Fixation and Instance.
- **Process:** Performance and Communication.

A part from identifying the key concepts in the creation submodel, it also includes some relations among them and a set of constraints on how they are interrelated. More details for this point and the following steps in the conceptualisation process are available from[8].

Second, there is the rights submodel, which is also part of the static part model. The Rights Model follows the World Intellectual Property Organisation (WIPO[9]) recommendations in order to define the rights hierarchy. The most relevant rights in the DRM context are economic rights as they are related to productive and commercial aspects of copyright. All the specific rights in copyright law are modelled as concepts. For the economic aspects of copyright there are the following rights: Reproduction, Distribution, Public Performance, Fixation, Communication and Transformation Right.

Each right governs a set of actions, i.e. things that the actors participating in the copyright life cycle can perform on the entities in the creation model. Therefore, it is time to move to the dynamic aspects of the domain. The model for the dynamic part is called the Action Model and it is built on the roots of the two previous ones.

Actions correspond to the primitive actions that can be performed on the concepts defined in the creation submodel and which are regulated by the rights in the rights submodel. For the economic rights, these are the actions:

- **Reproduction Right:** *reproduce*, commonly speaking *copy*.
- **Distribution Right:** *distribute*. More specifically *sell*, *rent* and *lend*.
- **Public Performance Right:** *perform*; it is regulated by copyright when it is a public performance and not a private one.
- **Fixation Right:** *fix*, or *record*.
- **Communication Right:** *communicate* when the subject is an object or *retransmit* when communicating a performance or previous communication, e.g. a re-broadcast. Other related actions, which depend on the intended audience, are *broadcast* or *make available*.
- **Transformation Right:** derive. Some specialisations are *adapt* or *translate*.

At this point we have completed the first phase of the dynamic model part, i.e. the verb concepts have been identified. They constitute the key elements in order to build knowledge expressions that represent the processes, events and situations that occur in the copyright domain.

In order to build this expression and relate the verb concepts to the other participants, i.e. concepts in the creation submodel or reused from other ontologies, it is time to complete the dynamic model and detail for each verb concept the corresponding case roles.

Due to space limitations, this section includes just the detailed model for the *Copy* action, which is formally known as *Reproduce*. However, it is commonly referred to as *Copy* and this term is the one that is going to be used in the ontology in order to improve its usability. Copies have been traditionally the basic medium for *Work* commercialisation. They are produced from a *Manifestation,* from a *Fixation* of a *Performance* or from another *Instance*. Therefore, these are the *theme* of the *Copy* verb as it is shown in Table 3.

The result is an *Instance* that is the item employed for the physical commercialisation of works, i.e. when a physical item is used as the vehicle to make the *Work* arrive to its consumers. For example, the making of copies of a protected work is the act performed by a publisher who wishes to distribute copies of a text-based work to the public, whether in the form of printed copies or digital media such as CD-ROMs.

Table 3: Copy case roles.

Case role	Range	Cardinality
agent	Person (Natural or Legal)	1..N
theme	Manifestation OR Fixation OR Instance	1
result	Instance	1
pointInTime	e.g. ISO8601	1
location	e.g. ISO3166, URL, ...	1
...	...	...

The central part of Figure 1 shows an example model for expression build using the proposed pattern as it is applied to the Copy verb concept. This kind of action patterns are also used to model licenses. Therefore, two additional verb concepts are identified and detailed using case roles: *Agree* and

[8]A Semantic Web approach to Digital Rights Management, http://rhizomik.net/~roberto/thesis
[9]WIPO, http://www.wipo.int

Disagree. They are the building block of any license. Figure 1 shows a license for the *Copy* action previously introduced. As it is shown, the *condition* case role is used in order to introduce a compensation for the agent that grants the copy action, a 3€ transfer from the granted agent.

As it can be observed in the figure, the *condition* case role is used to model the obligation deontic aspect inherent in copyright licenses. The permission and prohibition deontic aspects also present in licenses are captured by the *Agree* and *Disagree* verb concepts and their corresponding *theme* case roles.

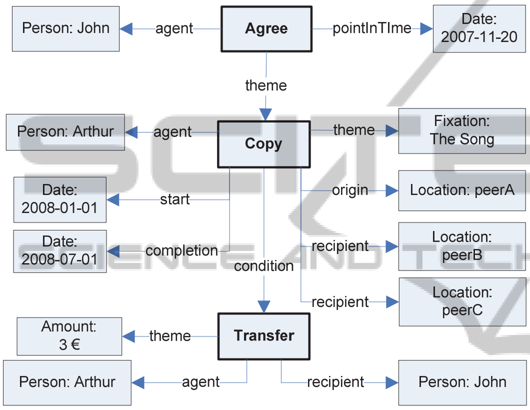

Figure 1: Model for an agreement on a copy action pattern plus a condition.

The agreement *theme* corresponds to an implicit permission, i.e. the theme of an agreement is permitted. The *condition* relation corresponds to an obligation, i.e. in order to fulfil the theme action it is necessary to satisfy the pattern defined by the condition property object. Finally, it is also possible to model prohibitions using the *Disagree* verb concept and placing the prohibited action in the corresponding *theme*.

As a result of the Copyright Ontology development process, it has been possible to test the first objective of the proposed ontology-engineering pattern. It facilitates the ontology conceptualisation because it provides a predefined pattern to face the conceptualisation process and a predefined set of constructs, the proposed case roles, which facilitate building a detailed model for the dynamic model aspects.

A part from the Copyright Ontology conceptualisation presented in this section, there is an implementation[10] based on the Web Ontology Language (OWL), concretely on the Description Logic (DL) variant. This implementation can be used to develop a Semantic DRM System based on DL reasoning (García and Gil, 2010), as detailed in the next section.

4 USE CASE

The Copyright Ontology has been applied in a real use case involving media fragments and existing DDEX rights data. DDEX data is used in this case as the way to communicate the rights associated to assets along the value chain. However, DDEX data does just model deals, which capture the kind of actions that can be performed with a particular asset or fragment in a given territory, time point, etc. They do not capture the existing copyright agreements that might make those particular actions legal or not. Table 4 includes a DDEX example.

Table 4: DDEX data example.

```
<Deal>
    <DealTerms>

    <CommercialModelType>PayAsYouGoModel
             </CommercialModelType>
        <Usage>

    <UseType>OnDemandStream</UseType>

    <DistributionChannelType>Internet

    </DistributionChannelType>
        </Usage>

    <TerritoryCode>ES</TerritoryCode>

    <TerritoryCode>US</TerritoryCode>
        <ValidityPeriod>
             <StartDate>2013-01-
01</StartDate>
        </ValidityPeriod>
    </DealTerms>
</Deal>
```

Consequently, if there is a dispute because an asset or fragment is detected under a conflicting use, it is difficult to determine if there is legal support to claim compensation. Many different DDEX deals might be involved and even the agreements related with the involved assets might have to be manually checked. This is not feasible if the amount of disputes to deal with grows.

DDEX has been mapped to the Copyright Ontology, some of the mappings are shown in Figure 3, so DDEX data can be converted into Semantic Web data based on this ontology. This

[10]Copyright Ontology, http://rhizomik.net/ontologies/copyrighton to

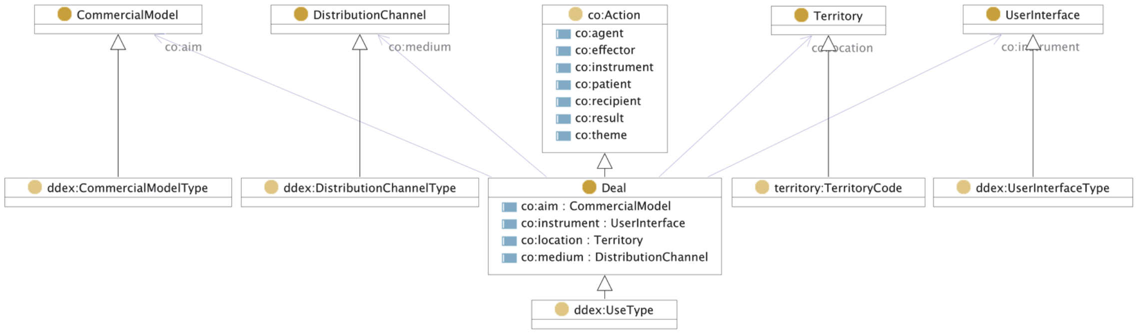

Figure 2: Illustration of Copyright Ontology-based reasoning to check if a dispute is supported by existing rights agreements that defines two deals.

way, many different deals can be combined and taken into account to decide a dispute. Moreover, they can be also combined with other sources of information, like existing agreements once they are also formalised.

Table 5: DDEX data example modelled using the Copyright Ontology.

```
<http://media.com/deals/3>         owl:Class,
msp:Deal;
    co:start "2013-01-01" ;
    co:aim  ddex:PayAsYouGoModel ;
    owl:intersectionOf (
        ddex:OnDemandStream
        [ a owl:Restriction ;
            owl:onProperty co:theme ;
            owl:hasValue

    <http://my.tv/video.ogv#t=60,100> ]
        [ a owl:Restriction ;
        owl:onProperty co:medium ;
            owl:someValuesFrom ddex:Internet
]
        [ a owl:Restriction ;
            owl:onProperty co:location ;
            owl:someValuesFrom
            [ a  owl:Class ;
                owl:oneOf      (territory:ES
territory:US) ]
        ]) .
```

Once combined, it is possible to use reasoners to easily implement the process of checking if the dispute being considered is supported by any of the existing deals or agreements. To do that, deals are modelled as classes based on the intersection or union of restrictions on the deal action and its case roles, as shown in Table 5.

These classes define the set of actions that are authorised by a deal. The reasoner can be then used to check if the dispute, modelled as an instance, is inside the set defined by the class and consequently it can be interpreted as supported by the deals and the agreement under consideration, as illustrated in Figure 2.

This process is based on the instance classification service provided by OWL reasoners so the implementation effor is reduced to retrieving the classes modelling the deals where the intance has been classified into and checking if it is part of an agreement and thus licensed. It is also checked that the there is no deal the instance has been classified into that corresponds to a disagreement, the way the Copyright Ontology models prohibitions and exceptions. More details about copyright reasoning are available from [11].

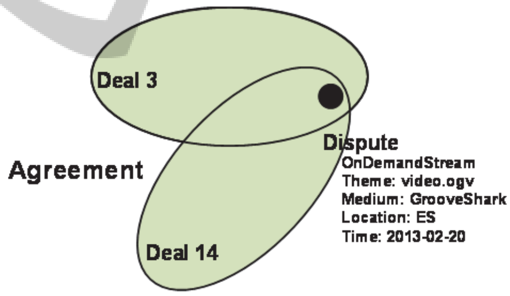

Figure 3: Mappings among DDEX and Copyright Ontology concepts.

5 CONCLUSIONS AND FUTURE WORK

As the amount of media in the Web increases and more sophisticated uses like reuse are considered at that scale, a way to represent and automatically process media rights becomes even more necessary. This problem becomes even more relevant when not just the copyright of pieces of content has to be

[11]Copyright Reasoning Explained, presentation available from MediaMixer Community (free membership). http://community.mediamixer.eu/materials/presentations/copyright/view

considered, but also media fragments.

To provide a scalable solution, we propose using highly expressive rights representations that can be connected to media fragments. This proposal is materialised into a Copyright Ontology, which is based on Semantic Web technologies. The ontology provides a common framework, based on copyright law, capable of giving support across the whole media value chain.

Existing data formats can be mapped to this common framework and then benefit from formal semantics. First of all, media fragment can be identified using the W3C Media Fragment URI recommendation. Moreover, existing data, like DDEX data used by the industry to communicate information across the value chain, can also be mapped to the Copyright Ontology.

Once integrated and formalised, it becomes easier to implement solutions at the Web scale using existing Web ontologies reasoners. This approach has been put into practice in a real use case, where existing DDEX data is converted into semantic data and connected to the Copyright Ontology. Then, reasoners have been used to help decide if a dispute on a media fragment is supported by the existing DDEX data and copyright agreement and thus it is possible to ask for compensation.

Future work now is to bundle this solution into an existing asset management system like Fedora Commons[12], which is also incorporating semantic technologies and media fragments capabilities. This setting would help further evaluation the Copyright Ontology in real use cases, pushing boundaries to test its scalability and incorporating other rights data sources, like rights agreements automatically processed using Natural Language techniques.

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[12]http://fedora-commons.org