USING A STANDARDS-BASED APPROACH FOR A MULTIMEDIA KNOWLEDGE-BASE

Maria Ilaria Lunesu, Filippo Eros Pani and Giulio Concas
Department of Electrics and Electronics Engineering, University of Cagliari, Piazza d'Armi, Cagliari, Italy

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Abstract: In recent years, we witnessed the diffusion and rise in popularity of software platforms for User Generated Content management, especially multimedia objects. These platforms handle a big quantity of unclassified information. UGC sites (i.e. YouTube and Flickr) do not force the users to perform classification operations and metadata definitions, leaving space to a logic of free-tags (Folksonomies). In the context of an industrial project financed by the Autonomous Region of Sardinia, the idea of producing a Geolocalized Guide based on a Knowledge-base came forth. Such Guide would be able to share georeferenced content with their users, originated from UGC sources as well as from users themselves. For this purpose, we defined an ontology that can represent the semantics of multimedia content, especially its metadata, which in turn can be given an unambiguous meaning. The innovation in this work is represented by the use of the Adobe XMP, DUBLIN CORE, EXIF, IPTC standards as a starting point. In order to unify metadata coming from different sources we defined all laws of mapping toward a structure defined by sources like YouTube and Flickr.

1 INTRODUCTION

It has been observed how, in recent years, many software platforms managing big quantities of multimedia content have risen in popularity within the Web-2.0. UGCs in particular, the most famous of which are Youtube, Flickr, Del.icio.us, Zooomr, Picasa, own their great success to a spread of digital technology accessible by a mass, paralleled by the quantity and quality of the services offered. The prominent features of such platforms are their ease of use, the possibility for users to create and manage their own spaces (personal channels or pages), carrying and sharing any kind of multimedia content from various sources, the implementation of efficient content research and localization methods, the definition of access and usage types for them, and storage of information about legal restrictions and rights management. When the first problems about interoperability of applications and management of shared means arose inside those platforms, moving on to a more effective representation of knowledge became a necessity, along with the evolution of the Web in its semantic form named Web 3.0.

In particular, we wanted data and resources to be conceived and represented not through a description of their structure (syntax), but by a definition of their meaning (semantics), and for this to be shared within the community using those same data.

In the context of an industrial project financed by the Autonomous Region of Sardinia, we fostered the idea of developing a Guide based on a Knowledge-base which could manage content from UGC sources like Flickr and YouTube available for their users, in addition to contents the users add into the system, with georeferenced information.

The purpose of this study is to give an unambiguous meaning to those information so that they can be managed with a single Knowledge-base.

In order to achieve this goal we chose to define an ontology that is able to represent the semantics of these multimedia contents and their metadata, with the most used standards to define metadata in this domain (Adobe XMP, DUBLIN CORE, EXIF, IPTC) as starting points as proven by Gruber (2008).

The innovation of this work is that we chose to base our approach on the use of the Adobe XMP standard as a description of the domain of multimedia metadata, which gives the opportunity to exhaustively represent multimedia content and its metadata as well as the other mentioned standards (DC, EXIF e IPTC).

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In the second section of this paper we recall some aspects about the state of the art concerning ontologies and standards used to represent metadata related to multimedia contents.

In the third, we present our methodology and address the analysis of the metadata typical of our two UGC sources, Youtube and Flickr, and Folksonomies. We also describe the testing done, with a description of the different phases of ontology building and mapping technology we developed.

The fourth section includes the conclusion and reasonings about the future evolution of the proposed project.

2 STATE OF THE ART

2.1 Standard Description

Ontologies are an increasingly popular tool thanks to the advantages they offer when sharing information. For a few years they have played a leading role in the representation and utilization of knowledge processes. In the past, the study of ontology focused mainly on its philosophical context, but recently it has assumed an important role in a different research and industrial section. Ontologies are in fact able to isolate, retrieve, organize and integrate information according to their core feature, their semantic context. Multimedia Ontologies have many application fields, including Content Visualization, Knowledge Sharing and Learning as proven by Jaimes and Smith (2003) and by Kameas and Seremeti (2007). Their structure and semantics are accurately modelled to be broadly consistent with existing multimedia description standards like MPEG-7 as shown by Martínez, Koenen and Pereira (2002).

There are two different approach to this kind of ontologies. Media-Specific Ontologies (that use different kinds of multimedia taxonomies and describe different kinds of object properties) and Content-Specific Ontologies (that describe the content of resources, e.g. the scenarios or the participant) as proven in Alesso and Smith (2008).

The construction of multimedia ontologies is rather complex, it is an iterative process whereby a phase for the selection of concepts to include in the ontology, a phase to create properties and relations linking them together, and a phase for maintenance of the ontology. We could mention many attemps to create a multimedia content ontology. In (Jaimes and Smith, 2003) and (Benitez and Chang, 2003) new methods for extracting semantic knowledge from data are presented.

In (Strintzis et al., 2004), we used a Visual Descriptors Ontology and a Multimedia Structure Ontology with a domain ontology that aims to support the note of content. There are other works as shown in (Bertini et al., 2005), (Bertini et al., 2006), (Petridis et al., 2006) that are not applicable in this contest.

As regards our work (that we will describe in the next sections) we referred to standards as domain reference, which fit with the management and categorization of different types of content and georeferenced data. These standards will be described below.

2.1.1 XMP Standard

The Adobe Extensible Metadata Platform (XMP) is a standard, created by Adobe Systems Inc., for processing and storing standardized and proprietary information relating to the contents of a file.

XMP standardizes the definition, creation, and processing of extensible metadata. Serialized XMP can be embedded into a significant number of popular file formats, without breaking their readability by non-XMP-aware applications. Embedding metadata avoids many problems that occur when metadata is stored separately. XMP is used in PDF, photography and photo editing applications.

XMP encapsulates metadata inside the file, using RDF (Resource Description Framework), a basic tool proposed by W3C for encoding, exchange and reuse of the structured metadata as proven by W3C. The standard allows, in addition to other things, interoperability between the different applications that interact on the web. The reason for its use is that it is a common standard for a wide range of applications, which allows us to work efficiently and effectively on metadata. These properties have encouraged the rapid spread at many companies operating in the digital media, which integrate their applications with this technology. XMP has been designed and thought also to define, create and elaborate user-defined metadata which are compliant with the standards.

2.1.2 Dublin Core (DC) Standard

Dublin Core is a standard for metadata that consists of a core of essential elements for the description of any digital material accessible via a computer network as proven by (Becker et al., 1977). They proposed a set of 15 basic elements extended also to sub-elements or qualifiers: each element is defined using a set of 10 properties obtained by a standard ISO 11179. The main features of DC are follows:

1) ease of use the standard is aimed at specialized cataloguers which are not experts in cataloguing, as users;

2) semantic interoperability, which gives rise to a complex and precise data system the meaning of which has been agreed in advance, along with a value that allows the DC to be a standard for quality research in Internet; flexibility, as it allows you to integrate and develop the data structure with different semantic meanings and a congenial application environment.

2.1.3 EXIF Standard

The EXIF standard was created by Japan Electronics and Information Technology Industries Association for metadata of digital images. This is a structure supported by the main producers of cameras and is studied to give users the opportunity to supply photos with interchangeable information between imaging devices to improve processing and printing.

The rapid spread of digital cameras and related tools increased the need to exchange images directly from cameras or other instruments, or to display an image taken with a camera through either another, or a different device altogether.

EXIF offers a set of specific tags in itself, concerning shooting parameters and settings of the device at the time of capture (JEITA, 2002).

2.1.4 International Press Telecommunication Council (IPTC) Standard

IPTC is a standard that offers an advantage to relations and exchanges among entities devoted to information creation and distribution. It is sponsored and defined by a consortium based in London that encompasses the leading news companies in the information world, such as Reuters, Associated Press and France Press. IPTC does not hold, among its metadata, fields related to technical information on a digital object; in fact, the metadata of the digital object itself, present in other standards like EXIF, are not defined. The focus of IPTC in defining the standard is on analyzing what surrounds the many situations of telecommunications, and on studying their production process. Therefore, a range of metadata were defined, which are useful to define and certificate all digital object production activities for print or editing (IPTC, 2008).

2.2 Support Tools

The work needed a preliminary and careful study of ontologies and the most suitable tools for ontology editing. We chose Protégé (Stanford Center for Biomedical Informatics Research), a knowledge-base and open source framework developed at Stanford University.

Protégé is able to implement a rich set of structures and knowledge-modelling actions to support creation, viewing and manipulation of ontologies in various representation formats.

Below is an overview of the software platforms analyzed and taken as an example for mapping strategy development.

2.3 YouTube

YouTube is an Internet site for video sharing. Founded in February 2005 by Chad Hurley, Steve Chen and Jawed Karim (all former PayPal employees), it is now property of Google Inc. It is the third most visited site in the world next to Google itself and Facebook.

YouTube uses the Adobe Flash technology to play its contents, and it aims to host only videos created directly by the uploader. This platform makes an intensive usage of feeds containing objects, such as web link to content sources. The interaction between YouTube and clients is managed through a protocol named YouTube Data API Protocol, a program communication interface application.

The data existing in the API are shown by the protocol as views or projections, with the ability to modify the form a feed is to be presented with. However, content is preserved as it is. In this way, two different projections from the same feed will identify the same objects, but using different XML tag sets in (Bray et al., 1998) and (W3C, 2007).

2.4 Flickr

Flickr, developed by Ludicorp (a Canadian company in Vancouver founded in 2002), is a multilingual web site that allows users to share personal pictures with whoever has access to the Internet, in a Web 2.0 environment. The site, owned by the Yahoo! group, has an ever growing library and was one of the first to implement tag clouds, visual representations of user-generated tags. Tag clouds allow access to images tagged with the most popular keywords. Thanks to this support for tags, Flickr was mentioned as the first example of actual folksonomy use, although Thomas Vander Wal suggested Flickr is not the best example (Vander Wal, 2007).

Flickr supports standard metadata sets (it shows the entire Exif metadata set for every picture), keywords for searches and a group of tags belonging to folksonomies.

As far as the georeferencing is concerned, Flickr allows users to organize their pictures in 'sets', that is groups of images sharing the same gallery. Sets are more flexible than the traditional folder organization method for files: a picture can belong to one or more sets, or to none. Those sets represent a form of category metadata, instead of a physical hierarchy.

The pictures in a set can be geotagged, and every set of geotagged pictures can be put in relation with a map using ImapFlickr2. Such a map can then be embedded in Web sites.

2.5 Folksonomies

Folksonomies are a set of terms used by a group of users to tag its own contents (Vander Wal, 2007).

An important aspect of folksonomies is that they are made up of terms belonging to an open namespace, i.e. there is neither a hierarchy nor a parent-child relation among the terms. The only standard they conform to is the one the tags are formalized with: namespace:property=value (with no rules on the other three parts that complete the assertion) (Vander Wal, 2005); (Mathes, 2004).

3 ONTOLOGY BUILDING

Considering the current literature, the approach we followed in building a multimedia content ontology assumes the XMP, Dublin Core, EXIF and IPCT standards, as well as the related XML schemas and the integration with the semantics through RDF, as a basic Knowledge-base for the starting domain as proven by Lassila and Swick (1999) and by Brickley and Guha (2000). Thus a complete modelling of the domain of multimedia content properties, coming from different sources, is guaranteed together with an uniform representation of the variety of associated metadata.

The reason for choosing this approach lies in the fact that such standards allow for cataloguing different aspects of multimedia content and natively possess the specification tools for georeferenced information. The ontology was then modelled on those standards, selecting the relevant elements.

Once the basic ontology was decided, an analysis on cataloguing and classification of metadata in contents from the main software platforms of the Net followed. Thanks to this we could acknowledge alternative standards and proprietary formats used.

Given the great number of available platforms on the Net and since analyzing all of them would have been too onerous for us, it was necessary to narrow the scope and choose which ones should be considered.

After a study of all the features related to metadata on the chosen UGC sites, we worked on a mapping mechanism that allows such data and associated metadata to be represented within the ontology.

3.1 Ontology Modelling on Standards

The first step in creating an ontology implies acquiring knowledge about the domain to be modelled (Noy and McGuiness, 2001). In order to do this, we started from the assumption that the reference domain is the one that includes every kind of multimedia content, both currently available in the web or through modern digital technologies, equipped with sets of metadata belonging to the above mentioned standards.

The purpose of the ontology is to model the semantics of metadata from various multimedia contents, providing for georeferencing and mapping of the different standards related to metadata. Their representation can thus comply with the reconciliation standard provided by the MWG and with Adobe XMP.

The ontology must be able to receive a content coming from social networks or software platforms for content management without information loss or alteration.

The resulting ontology can be used as a Knowledge-base supporting the Geolocalized Guide.

As per the definition of the ontology, we chose to categorize the concepts according to the expression sublanguage named OWL DL (Description Logic), due to its computational completeness, its decidability and the fact it guarantees maximum expressivity (Carroll and De Roo, 2004); (McGuinness and Van Harmelen, 2004); (Heflin, 2004). The structure of the ontology was created by modelling the concepts mentioned above as classes or properties, following a middle-out approach. First of all we proceeded with the definition of relations and main entities which were progressively generalized and specialized.

These structures were integrated with RDF schemas. In particular, the entire set of metadata required by the EXIF standard, together with the entire Dublin Core set (complete with its *refiniment* terms), was imported. Both schemas allow the ontology to exploit their metadata, making them available as particular properties, *datatype properties* and *object properties* at the same time, probably so as to satisfy every kind of usage needs.

In this specific case they were used solely as object properties, i.e. to link class instances with other class instances. The main classes involved in ontology building are basically four:

1) MultimediaContent: this class models the concept of multimedia content. It is a simple class, without subclasses, which formalizes its link with the class representing file formats (MultimediaFormat).

2) MultimediaFormat: represents the most common file formats currently available in the Net. This class has a two-level hierarchy. The first level represents format file categorizations depending on the content type they express. The second level is represented within each categorization, where classes, representing the actual formats, are located. Each format is identified by its own extension.

3) Metadata: its subclasses represent every type of metadata considered in the study of reference standards and reference application context.

4) XMPtype: all properties concerning the Metadata class and its subclasses have the XMPtype class as codomain. It includes a number of classes which represent the different data type the XMP standard uses to describe information inside its tags. One problem is that some applications avoid the complex operation that stores information inside files. They opt instead for executing it in external files or databases, although that operation could lead to the loss of metadata as well, when the same file is used in different applications. XMP, for example, is one of the standards that requires writing of its own metadata set inside the file, but it is not the only standard that enables this action. Every file format often has its own blocks, different from the ones XMP uses, to store certain metadata schemas. For example, a JPEG image has some containers for storage of the EXIF, IPTC-IIM, and Photoshop standards.

Metadata are stored in different semantic groups inside each block. For example, the following groups can be found inside the XMP APP1 block: Dublin Core, IPTC-Core, EXIF/TIFF; inside the Photoshop APP13 block is the IPTC-IIM group.

This problem required a data reconciliation which was performed through the mapping technique. The creation of the mapping meant the execution, where feasible, of a set of non-automatable, strongly subjective operations.

The search for XMP tags that could map the ones used on the analyzed platforms was an integral part of our work.

We searched for tags with the same semantics as the ones we needed, among those available in the standards within XMP. This search was performed with particular care so as to avoid mistakes due to unclear or poor descriptions and consequent semantic association mistakes.

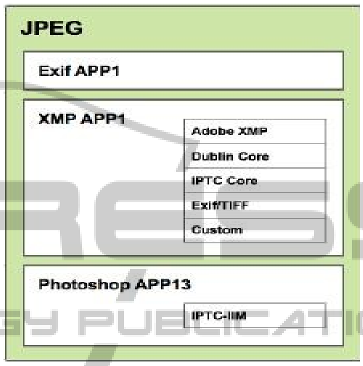

Figure 1: XMP block's Schema.

3.2 Mapping of UGC Metadata

YouTube. A significant part of the metadata used by YouTube was used in order to define the Ontology.

One of the problems we faced during the mapping was reducing the semantics of certain tags to a single representation.

Each tag was represented with all of its attributes and subtags within the ontology. The significance of the information YouTube associates with some tags depends on the feed where they appear.

The set we chose to represent was the one related to the video feed, i.e.:

```
id,published?,updated,category*,title,c
ontent?,link*,author?,gd:comments?,
media:group?,yt:statistics?,gd:rating?,
yt:location?,yt:recorded?,yt:accessCont
rol+ georss:where?, app:control?
```

This subset describes the information related to videos, which are the main content of YouTube, and has pieces of information that are to be taken into account when complying to specifications, such as comments and georeferencing information.

However, due to the importance of YouTube, this subset was represented whole in the Ontology. Non-mappable tags were created *ex novo* as well as implication relations that could tie together mappable tags with 'mapping' tags.

Table 1: XML Schemas and related namespaces.

Schema	Namespace Prefix	Schema URL
Atom Syndication Format	Default namespace	www.w3.org/2005/Atom
Open Search Schema	openSearch	A9.com/-/spec/opensearch/1.1
Media RSS	media	Search.yahoo.com/mrss
YouTube XML Schema	yt	Gdata.youtube.com/schemas/2007
Google Data Schema	gd	schemas.google.com/g/2005
GeoRSS	georss	www.georss.org/georss
Geography Markup Language	gml	www.opengis.net/gml
Atom Publishing Protocol	app	www.w3.org/2007/app
Google Data API Batch Processing	batch	schemas.google.com/gdata/batch

The mapping happened in two different ways, depending on whether the semantic correspondence was direct (same meaning of information, and same format, same data type as well) or indirect, that is to say there was discordance in its form (same meaning but different representation. In the direct case, we exploited the feature by which it is possible to create property hierarchies: each property can have its own subproperties, which specialize their superproperties just like a subclass specializes a superclass. This means that an implication relation among nested properties is in place: if the superproperties have a domain and a codomain, those will be necessarily inherited by their subproperties. Even on a visual level, mapped tags will appear under the mapping ones. Therefore direct mappings were performed by assigning the mapped tag its mapping tag as superproperty.

To make such operation clearer and the ontology more readily accessible by users, every direct mapping came together with an annotation of the rdf:comment type with information related to the 'mapping' tag.

On the other hand, in the indirect case the implication relation cannot be used, because the information must be broken down in its elementary parts first, and then those parts must be traced back to direct mode. These steps are described inside the rdf:comment associated to the mapped tag.

In particular it explains how to split and convert the information, and where to store it.

Flickr. Our approach to Flickr was quite different compared to YouTube. It was firstly because of how metatada related to available content were managed, and secondly due to the lack of documentation about them. Initially Flickr used to equip its content with a simple set of pure Exif data, so natively mappable in the ontology because they strictly complied with the standard.

Folksonomies. In the more recent years a reversal took place, and metadata in Flickr started becoming part of the so-called Folksonomies. As previously discussed on section two, the usage of folksonomies causes metadata not to belong to any kind of hierarchy. They become unidentifiable in a namespace and make recognition and mapping impractical. For this reason the tags of Flickr not included in the Exif standards were represented with a class called 'FlickrFolkosomies' inside the ontology. This class has, as a property, a set of tags that allow to generate a Feed Atom, that in turn includes all such information in bulk, non-standardized.

Metadata belonging to standards but non-mapped and lacking on the ontology Knowledge-base were mapped and presented in the same way.

In particular, the set of unknown metadata or metadata belonging to folksonomies must be stored inside the Atom Syndication Format tag atom:content. “This specification describes Atom's XML markup vocabulary. Markup from other vocabularies (foreign markup) can be used in an Atom Document. Note that the atom:content element is designed to support the inclusion of arbitrary foreign markup.” (The Internet Society, 2005).

3.3 Mapping Example

We shall now consider the mapping applied to the metadata related to the 'Hammamet' picture on Flickr. The metadata associated to this picture by Flickr are listed in Table 2.

These metadata are partly complying with the Exif standard (and mapped with the typical rules of the standard as such) and partly belong to Folksonomies.

The above mentioned mapping rules were applied, and part of the data were inserted, while the rest was inserted in the FlickrFolksonomies class.

Table 2: Tag EXIF.

Fotocamera	Panasonic DMC-FS5
Esposizione	0,002 sec (1/640)
Aperture	f/5.6
Lente	5.8 mm
ISO	100
Exposure Bias	0 EV
Flash	Auto, Did not fire
Orientation	Horizontal (normal)
X-Resolution	180 dpi
Y-Resolution	180 dpi
Software	f-spot version 0.5.0.3
Date and Time (Modified)	2009:08:21 19:02:51
YCbCr Positioning	Co-sited
Exposure Program	Landscape
Date and Time (Original)	2009:08:19 08:07:14
Date and Time (Digitized)	2009:08:19 10:07:14
Compressed Bits Per Pixel	4
Max Aperture Value	3.3
Metering Mode	Multi-segment
Light Source	Unknown
Color Space	sRGB
Sensing Method	One-chip color area
Custom Rendered	Normal
Exposure Mode	Auto
White Balance	Auto
Digital Zoom Ratio	0
Focal Length In35mm Format	33 mm
Scene Capture Type	Standard
Gain Control	None
Contrast	Normal
Saturation	Normal
Sharpness	Normal
Image Quality	High
Firmware Version	0.1.1.2
White Balance	Auto
Focus Mode	Auto
AFMode	3-area (auto)?
Image Stabilization	On, Mode 2

Table 2: Tag EXIF (cont.).

Macro Mode	Off
Shooting Mode	Scenery
Audio	No
Data Dump	(Binary data 8200 bytes, use -b option to extract)
White Balance Bias	0
Flash Bias	0
Internal Serial Number	AAAAAAAAAAAAAAAAAAAAA
Panasonic Exif Version	0260
Color Effect	Off
Time Since Power On	00:00:49.25
Burst Mode	Off
Sequence Number	0
Contrast	High
Noise Reduction	Standard
Self Timer	Off
Rotation	Horizontal (normal)
Color Mode	Normal
Optical Zoom Mode	Standard
Conversion Lens	Off
Travel Day	n/a
World Time Location	Home
Text Stamp	Off
Program ISO	n/a
Maker Note Version	0121
Scene Mode	Scenery
WBRed Level	1833
WBGreen Level	1054
WBBlue Level	1964
Flash Fired	No
Compression	JPEG (old-style)
Orientation	Horizontal (normal)

As for the mapping, it was necessary to manually enter what was not provided for by the scheme of the ontology. We inserted the information related to all properties and created the link amongst them and between them and the various metadata so that they could be represented univocally and no information could be lost. In our example the first thing to be created was, with the aid of the tool, the

MultimediaContent class; the name 'Hammamet' was then associated to it, exploiting the 'instance browser. It could be noticed that, for the properties previously created, the hasMetadataLocation and doesExpress fields appear already compiled.

On the other hand, we had to define the elements to insert in the hasMetadataDescription field and the ExifSchema,UnknownMetadata,ExifSchemaHammamet and UnknownmetadataHammamet instances.

The latter belongs to the class devoted to the representation of unknown metadata belonging to a standard.

At this stage, the ExifSchemaHammamet instance could be filled out with all the fields returned by the Flickr tool. In this way an univocal correspondence between information and metadata related to it was created.

The entire Exif schema must be checked in order to know which tags of the picture are present or not. We entered the missing data manually.

Once the values were ready to be entered into the tags, we created a different data-type instance for each data. Afterwards a Date_1-type instance was created for the tiff:dateTime tag.

Since the data type belongs to the EXIF schema, it requires some additional attributes for temporal information (`exif:subSecTimeDigitized,exif:subSecTimeOriginalexif:subSecTime`); thanks to the existing relations, the fields related to such attributes were displayed as well.

4 CONCLUSIONS

The purpose of this work was to study, design and create an ontology that could formalize the multimedia content semantics and geocoded data, starting from the most used standards in representing that domain, especially the Adobe XMP standard. The aim was to offer a structure enhanced with semantics, that could serve as base support for the creation of a software platform for web content management.

Another powerful tool is represented by the same shared standards: in fact, they guarantee interoperability, i.e. the ability for various technological systems and services to communicate and exchange information among themselves and with other systems, which is a feature of utmost importance. Given the way the ontology was organized and structured, we might think of its future application as a support to a software platform which would allow different subjects to develop high-value services based on the input of multimedia content in a context of semantic organization, integrated by localization services.

The system could be accessible through mobile devices such as PNAs (Personal Navigator Assistant), that would use a geolocalization system to know their location.

The platform, thanks to the modelled concepts, could give users the chance to collect and add contents originated from varied sources (websites, web portals, local files) and to influence the value of the contents though ratings, comments and preferences. Thus contents could be gathered, aggregated and geocoded, and then distributed to each user.

Such a platform should clearly be provided a powerful tool capable to “conform” every piece of information about the added contents to the form designated as representation standard within itself. In other words, it must be able to map any kind of metadata present in contents.

Once again the ontology we created would be an impressive tool for fulfilling that requirement.

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