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SCORM-MPEG: an Ontological Approach of Interoperable Metadata for Multimedia e-Learning

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Abstract

The convergence of digital media offers an integration of ICT focused on telecommunications and multimedia domain (under responsibility of the Moving Picture Experts Group, ISO/IEC JTC1 SC29) and the ICTE (the ICT for Education), managed by the ISO/IEC JTC1 SC36, highlighting the MPEG standards, employees as content and metadata to the Multimedia domain and technologies applied to e-Learning. Regarding this, there are problems of developing an interoperable matching for normative bases, achieving an innovative proposal in the convergence between digital telecommunications and applications for e-Learning, also essential to multimedia. To reach this purpose it is proposed to create a standard ontology of interoperable metadata for web, digital TV and extensions for mobile devices based on the integration between MPEG-21 and SCORM metadata standards. The methodology used consists of building ontology MPEG-21 SCORM which can be achieved on making a correspondence through the XPath language, managed by the W3C. The use of the XPath language is desirable for matching and mapping both metadata schema patterns – integrating MPEG-21 (mostly Digital Item Declaration Language) and SCORM metadata schema. The practical purpose is the creation and storage of objects for use in digital multimedia casting as the Web and Digital Television, in an interoperable way with the e-Learning industry, here as description metadata for all sorts of media and hypermedia to create learning objects.

Keywords: *e-Learning, Metadata, MPEG, Multimedia, SCORM.*

I. INTRODUCTION

The technological innovation issue comprehends a research in a hybrid field that comprises a breakthrough on the media convergence process, on purposing an interface between the norms and standard implemented in the field of interactive multimedia, highlighting the digital Multimedia (standardized by the ISO SC29[1] subcommittee), and the field of the technologies for e-Learning (standardized by the ISO SC36[2] subcommittee).

Technically, the e-Learning domain extends to the field of MPEG[3] multimedia, since it employs as its audiovisual content format the digital video standard MPEG-4 AVC H264, the worldwide industry standard today.

However, the standardization of the multimedia MPEG is not restricted to MPEG-4, since other MPEG technologies are in process of specification by the SC29 subcommittee and actually are more powerful in terms of metadata description and so on, as MPEG-7 and MPEG-21.

These distinct MPEG norms and its main defining characteristics are highlighted in the Figure 1, translated from the source reference in French [1]:

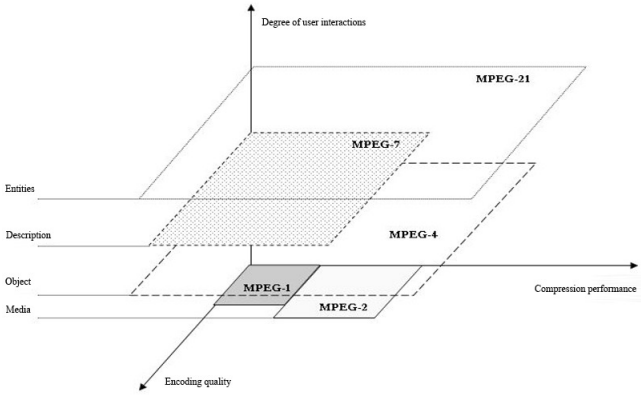

Figure 1. Different MPEG norms and its main characteristics in terms of encoding quality, compression performance and user interaction [1].

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[1] ISO/IEC JTC1 SC29, a standardization subcommittee in charge of the technical specifications within the field of audio, picture, multimedia, and hypermedia information coding.

[2] ISO/IEC JTC1 SC36, a standardization subcommittee that develops and facilitates standards within the field of information technology (IT) for learning, education and training.

[3] Moving Picture Experts, ISO/IEC working group established in 1988 with the purpose of developing and facilitating standards for coding representation of related data in digital audio and video.

It can be noted that the main characteristic for MPEG-4 is the possibility of object creation and manipulation. For MPEG-7, it would be the metadata description of all media content only; MPEG-21 allows the modelling of entities, on content and within an object oriented domain of descriptors.

MPEG21 become the most suitable option for metadata description as a breakthrough in this field since its framework allows not only content description, but all kinds of elements presented within the consumption channel, from the content and object creation, through broadcasting and reaching the end user (who otherwise can be also a producer).

Regarding this, the main objective on this work is contributing on the development of an interoperable matching between the normative bases in question, achieving an innovative proposal in the convergence between digital telecommunications and applications for e-Learning, also essentially multimedia, integrating MPEG-21 (mostly its *Digital Item Declaration Language*) and SCORM metadata schema. To reach this purpose the proposition is developing a standard ontology of interoperable metadata for web, digital TV and extensions for mobile devices based on the integration between MPEG-21 and SCORM metadata standards.

This hybrid standard would allow the creation and storage of objects for use in digital multimedia in an interoperable way with the e-learning industry, which in its turn employs all sorts of media and hypermedia technologies to create learning objects.

Regarding the challenges for the standardization of the ICT applied to e-learning, it comprises a telecommunications engineering problem still in developing the issue concerning how the MPEG Video family, especially the MPEG-21 [2] standard, could offer a normative basis for the implementation of multimedia metadata related to learning objects metadata.

This development demands the adoption and the usage of some tools to match all these learning and media objects, further to the content itself (video, still images, sound, text, hypertext etc), and must lie within a normative frame to guarantee interoperability, reusability and referring to the major platforms or digital environments in both fields, multimedia and e-learning.

For this purpose it was adopted in this research the XPath language, managed by the W3C[4].

The software engineering to support this normalization comprehends XML, MPEG-7, MPEG-21, themes approached by the SC36. Otherwise, ADL[5] experts, entity which developed the SCORM standard, are engaged in SC36 subcommittee too, and already proposed to in a certain way explore the capabilities of MPEG-21 to make this idea viable.

ADL strategy lies on capitalize the other subcommittees norms, and encourage the adoption of the Part 5 of MPEG-21 [3] (REL, or Rights Expression Language), to solve copyright issues, besides delegating to the LOM[6] standard its metadata description (or parts to other standards like IMS or DCMI – Dublin Core). This reveals a very converging approach and acceptation concerning the metadata and MPEG-21 issue on the industry and market.

II. Learning Objects and Metadata Standards

A Learning Object can be defined, in a perspective of Engineering, according to IEEE 1484.12.1 standard (Standard for Learning Object Metadata) [4], "For this standard, a learning object is defined as any entity, digital or non-digital, that may be used for learning, education, or training".

According to the IEEE LTSC [4], the LOM standard focus on the minimum attributes needed to allow a learning object to be found and evaluated. Metadata allow the cataloging and coding of the objects to turn them comprehensible within most e-learning platforms.

SCORM doesn't define itself a metadata model – it recognizes the LOM standard as the standard in fact [5]. Yet, SCORM defines XML as the syntax for metadata representation (process called *XML binding*). That is why LOM is used when representing SCORM metadata.

Within its CAM model published by ADL [5], SCORM defined in its part related to Metadata nine categories to describe learning objects attributes. The definition must be applied to assets, SCO (groups of assets), activities, content organizations and content aggregations, for their identification, categorization, consult and findability, to facilitate sharing and reusability.

To match specifications of theses metadata standards the proceeding is mapping their categories applying, in this research, the XPath language, as it was primary done mapping and matching DCMI–Dublin Core and SCORM metadata standards, as shown in Table 1. Mapping is expressed in XPath syntax.

As we can observe in Table 1, these identifiers cover from the most generic ones to the most specifics, related to the Rights, for example, which is a focus of ADL standardization concerning MPEG-21 and SCORM.

TABLE I. MAPPING OF SCORM AND DCMI METADATA (XPATH SYNTAX)

Matching SCORM (LOM) / DCMI	
SCORM	**DCMI**
/lom/general/identifier/entry	/dc/identifier
/lom/general/title	/dc/title
/lom/general/language	/dc/language
/lom/general/description	/dc/description
/lom/general/keyword ou /lom/classification/keyword com classification/purpose equals to "Discipline" ou "Idea"	/dc/subject
/lom/general/coverage	/dc/coverage
/lom/educational/learningresourcetype	/dc/type

[4] World Wide Web Consortium.

[5] *Advanced Distributed Learning*, iniciativa do governo americano datada de 1999, tendo como vetor o Departamento de Defesa, que tem a missão de recomendar e desenvolver padrões para software de treinamento.

[6] *Learning Object Metadata*, padrão de metadados ente os pioneiros, cujo *metadata schema* é adotado pelo padrão SCORM.

/lom/lifecycle/contribute/date com lifecycle/contribute/role equals to "Publisher"	/dc/date
/lom/lifecycle/contribute/entity com lifecycle/contribute/role equals to "Author"	/dc/creator
/lom/lifecycle/contribute/entity with the contributing type specified in lifecycle/contribute/role	/dc/othercontributor
/lom/lifecycle/contribute/entity com lifecycle/contribute/role equals to "Publisher"	/dc/publisher
/lom/technical/format	/dc/format
/lom/rights/description	/dc/rights
/lom/relation/resource/description	/dc/relation
/lom/relation/resource com relation/kind equals to "IsBasedOn"	/dc/source

III. Multimedia e-Learning Metadata

The metadata systems integration is already a longtime issue of investigation for the telecommunications community, mostly linked to multimedia broadcasting. In [1], [6], [7] and [8], we have samples of the discussion involving MPEG-7 and MPEG-21. Even the issue of learning through TV exhibition and SCORM was initially discussed [11].

MPEG-21 became the modular development and standardization platform (a framework) [12] towards global integration of all multimedia documents. The multimedia are not the product of an specific area of knowledge, but is a direct consequence of standardization of digital practices such as telecommunications, audiovisual, informatics.

Although the fact that MPEG-21 came up from a community that focuses on audio and video, the so called MPEG-21 Framework [12] can host all kinds of complex digital objects, such as electronic text, digital magazines, scientific data etc.

As can be seen from the scientific literature [13], [7] and [1] and from the norm itself [3], the MPEG-21 standard have a non-rigid structure of metadata, and Part 2 standard, DID, exposes the digital Item as the most generic approach for this purpose structural description of the use of metadata in digital objects of all kinds.

The MPEG-21 standard holds today 21 parts [3]. MPEG-21 is an XML-based metadata specification that brings two fundamental pillars: the definition of a unit or essential object of distribution and transaction, which is called Digital Item; and the notion of "reader" – the concept of users interacting with it.

The central concept within the MPEG-21 is the DI - Digital Item, as defined in Part 2 of the standard [12].

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The DID, or Digital Idem Declaration, relates a digital product, which can be simple or composite. A typical example is a webpage, containing different multimedia resources.

The use of MPEG-21 DIDL (Digital Idem Declaration Language) as a generic standard for the representation, cataloging and storage of digital learning objects in the library has been proposed by [14]. It demonstrated the applicability of the DIDL for representing complex objects of any type of media or content to create a digital collection in the library.

The second key concept in MPEG-21 format is the description of the production and interaction with the media, for all stakeholders in the process, from content producer to the end user. Therefore, it can be said that the main objective of MPEG-21 is to define the technologies needed to support the exchange, access, consumption, trade or handling of Digital Items in an efficient and transparent way [12].

IV. Methodology: a Convergent Ontology for the Integration Between MPEG-21 SCORM

Ontology between SCORM and MPEG-21 can be carried out by matching their syntax correspondences, through the W3C XPath language. The use of XPath language is directed to carry out the comparative study of mapping between the standards of SCORM metadata and MPEG-21, applying this methodology. XPath is a language maintained by the W3C with the primary objective of addressing parts of an XML document, and it is also used to test whether a code matches a pattern, or another code.

The MPEG-21, as already stated, provides the DIDL (Digital Item Declaration Language), but also other schemes and their languages, within other of the many parts of the standard, for the cataloging of objects and the flow of information, the case also DII (Digital Item Identification), and DIA (Digital Item Adaptation); but also for dealing with copyright data (MPEG-21 Part 5 REL - Rights Expression Language), CEL (Contract Expression Language), IPMP (Intellectual Property Management and Protection); and even use cases (UD - User Description).

The orientation of the work of JTC1 SC36, as can be accompanied by papers published by IEEE [13] and [17] is based essentially on the portability, interoperability and adaptability of technologies for education, teaching and learning. The SC36 does not, therefore, calling to extend the work carried out by other technical committees, such as the SC29 itself, the media committee, which deals with sound encoding, image, multimedia and hypermedia information.

However, the SC36 was a pioneer in pointing to the need for synergy with the SCORM MPEG-21 standard, proposition however limited to addressing issues of copyright and eventually the e-commerce of ICTE (Part 5 of the standard).

The MPEG-21 normalization lies in perfect continuity with the ones previously carried out within the MPEG-7 framework. And many MPEG-7 standard descriptors are part of the MPEG-21 metadata schema [12] scope.

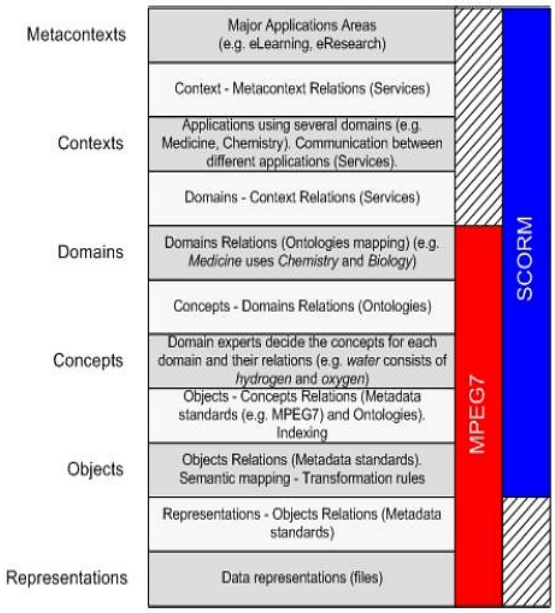
The descriptors and corresponding description schemes are developed under the responsibility of MDS group, whose data description is founded on the semantics of XML markup language.

The interrelationships between MPEG and e-Learning metadata standards are outlined in Table 2 [15] and in Table 3 [16]:

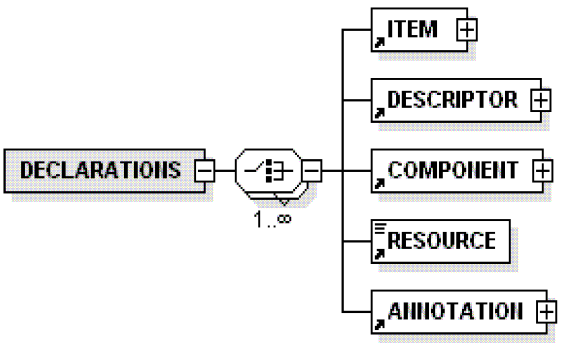
TABLE 2. MAPPING AMONG THE MPEG AND E-LEARNING MAIN METADATA STANDARDS [15]

	Métacontextes des applications	Relation métacontextes - contextes	Contexte des applications	Relation contextes - domaines	Domaines	Relation domaines-concepts	Concepts	Relation concepts-objets	Objets	Relation Objets-représentations	Représentations	Relation représentations-échanges	Echanges
DUBLIN CORE					■								
SCORM	■	■	■	■	■	■	■	■	■				
LOM			■	■	■	■	■	■	■				
MPEG-7					■	■	■	■	■	■	■		
MPEG-21					■	■	■	■	■	■	■	■	■

TABLE 3. MAPPING BETWEEN MPEG-7 AND SCORM [16]



DIDL documents are actually XML 1.0 documents. The DIDL syntax is based on an abstract structure defined in the Digital Item Declaration Model. This model defines the DIDL elements, namely: Container; Item, Component, Anchor, Descriptor, Choice, Selection, Condition, Annotation, Assertion, Resource, and Statement. These are structurally represented as Figures 2 and 3.



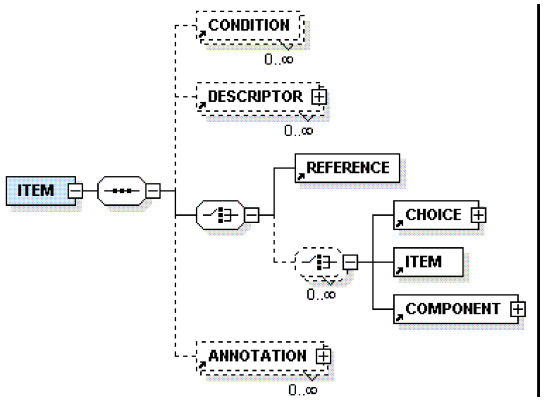


Figure 2. Partial graphical representation of DIDL schema [12]. Highlighting the Declarations and Item elements.

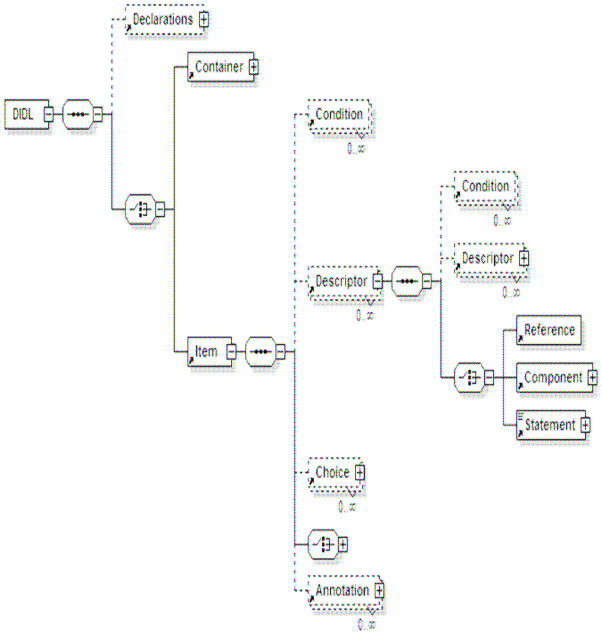


Figure 3. Partial graphical representation of DIDL schema [12] as a whole.

The DIDL XML code on the Declarations element (a special element that defines a selection of elements without instantiate them) would be displayed in the following generic form [12]:

```
<xsd:element name="DECLARATIONS">
    <xsd:complexType>
        <xsd:choice maxOccurs="unbounded">
            <xsd:element ref="ITEM"/>
            <xsd:element ref="DESCRIPTOR"/>
            <xsd:element ref="COMPONENT"/>
            <xsd:element ref="RESOURCE"/>
            <xsd:element ref="ANNOTATION"/>
        </xsd:choice>
    </xsd:complexType>
</xsd:element>
```

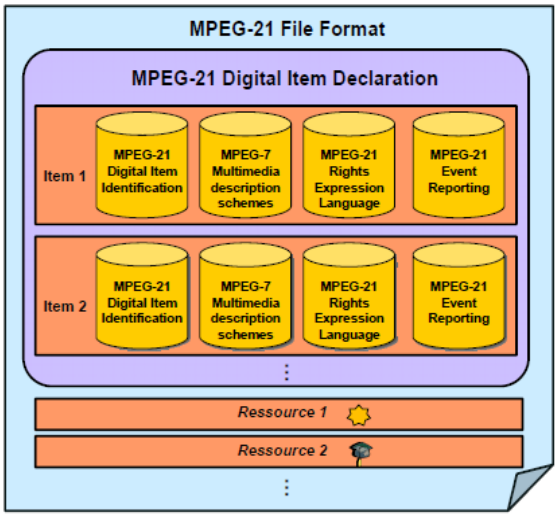


Figure 4. Hierarquical metadata structure within a MPEG-21 file [18].

To perform the integration of standard patterns, solutions are being implemented to make the correspondence between the categories of SCORM metadata and those defined by MPEG-21 metadata schema.

Using the XPath language as the default to format the taxonomies and create a new ontology, there were first mapped the following standard SCORM metadata (LOM), which would correspond to the multimedia standard MPEG-21, aligned to the concept of platforms convergence. As follows in Table 4:

TABLE 4. SCORM METADATA TO BE MATCHED WITH MULTIMEDIA MPEG-21 STANDARD, FOR WEB, MOBILE OR DTV

SCORM Multimedia Metadata	MPEG-21 Metadata (under development)
/lom/general/identifier/entry	<mpeg21>
/lom/general/title	<mpeg21>
/lom/general/language	<mpeg21>
/lom/general/description	<mpeg21>
/lom/general/keyword	<mpeg21>
/item[@identifier]	<mpeg7>
/lom/general/coverage	<mpeg21>
/lom/educational/learning/resource/type	<mpeg21>
/lom/lifecycle/contribute/role	<mpeg7>
/lom/lifecycle/contribute/date	<mpeg7>
/lom/technical/format	<mpeg7>
/lom/technical/size	<mpeg7>
/lom/technical/location	<mpeg7>
/lom/technical/duration	<mpeg7>
/lom/rights/description	<mpeg21>
/lom/relation/kind	<mpeg7>
/lom/relation/resource/description	<mpeg21>
/lom/relation/resource/catalogentry	<mpeg21>

V. CONCLUSIONS

Until the present moment it was possible to obtain successful results concerning the stages already overcame on this research, which progresses at an advanced pace regarding to the implementation of the specific goal of correspondence between metadata standards of the knowledge domains issued.

The development work has consisted in creating an Ontology focused on these mapped taxonomies in order to propose, from this ontology, an integration between the fields of Multimedia (on demand and streaming) and MPEG ICTE for Distance Education / e -Learning.

In other words, the convergence between MPEG-21 and SCORM as a standard for describing objects used for cataloging and for use in e-learning, in a broader sense, and e-learning via internet multimedia in a specific perspective of the field of research.

A SCORM MPEG-21 Ontology, using the W3C XPath language, is already in an advanced stage in order to make its contribution to the body of knowledge and the process of standardization in the metadata study domain.

It also contributes to a latent need for integration between the universes of Multimedia and e-Learning, represented by working groups of SC29 and SC36 standards subcommittees, ISO / IEC JTC1, in this context of convergence.

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