A new approach to interoperability between ODRL and MPEG-21 REL

Jaime Delgado, Jose Prados, Eva Rodríguez
Universitat Pompeu Fabra, Passeig de Circumval·lació, 8, 08003 Barcelona, Spain
{jaime.delgado, josep.prados, eva.rodriguez}@upf.edu

Abstract

A key issue for the real deployment of Digital Rights Management (DRM) systems is interoperability. A clear example is at the level of Rights Expression Languages (RELs), where two of them are a prominent role. On the one hand, ODRL (Open Digital Rights Language) is an initiative being used, for example, by the Open Mobile Alliance (OMA), a relevant industrial forum in the area of mobile and on the other hand systems MPEG-21 REL is an ISO/IEC standard. MPEG-21 REL is more complete, but rather complex although not exhaustive; this is why ODRL could be considered as a more flexible option.

In this paper, we analyse two DRM specifications from OMA, and try to propose its implementation in an MPEG-21 environment. In addition tools able to work in both environments are presented. By defining an MPEG-21 REL DTD, a minor extension of the MPEG-21 REL, and the use of the MPEG-21 IPMP (Intellectual Property Management and Protection), we are in fact specifying MPEG-21 REL profiles. This approach could simplify the implementation of MPEG-21 REL applications and facilitate its interoperability with ODRL. In order to verify the feasibility of our proposal, we have implemented some tools that work with both MPEG-21 REL and OMA DRM.

1. Introduction

In this paper we focus on the interoperability between Rights Expressions Languages, a clear key issue in order to achieve interoperability among complete DRM systems.

In [1] we presented a first approach to achieve interoperability between ODRL [2] and MPEG-21 REL [3]. In this first study we concluded that a syntactic approach to map licenses expressed in the two different languages would only be feasible for a subset of both languages, that could be identified as profiles.

As OMA (Open Mobile Alliance) [4] has developed the OMA DRM Rights Expression Language versions 1.0 [5] and 2.0 [6] based on ODRL, we have decided to define a specific subsets for MPEG-21 REL equivalent to those specified by OMA.

Therefore, in this paper we present how to achieve interoperability between MPEG-21 REL and ODRL for these specific subsets. The MPEG-21 REL subsets defined provides the same features as both OMA DRM RELs. For the first version presented by OMA, it is enough to restrict MPEG-21 REL to achieve interoperability, but for the second version of OMA DRM REL we also have to extend MPEG-21 REL as it does not provide all needed functionalities. OMA DRM REL v2.0 introduces the security and inheritance models that have not been considered in MPEG-21 REL. Then, we have extended the MPEG-21 REL to provide such functionalities. Nevertheless, in the case of security information, we have considered two approaches. In the first one, we have extended MPEG-21 REL defining the appropriate elements to describe the tools that protect the content, while in the second approach, we have used the MPEG-21 Intellectual Property Management and Protection (IPMP) Components [7] standard specification to describe and associate this information to the multimedia content.

Moreover, the subsets defined for MPEG-21 REL to achieve interoperability in the mobile domain and presented in this paper could also be considered as mobile profiles for MPEG-21 REL.

2. Rights Expression Languages

Digital Right Management (DRM) needs technologies to protect and securely deliver digital content. To achieve this, it is also needed to have a Rights Expression Language (REL), that is a formal language used to specify this protection and secure

delivery. A REL is a formal language, designed to express rights and conditions for digital content access.

A Rights Expression Language can be used for example to control the number of times that a right is exercised over a certain digital content, express the copyright associated to a given digital content, describe an agreement between a content provider and a distributor, or between a distributor and an end user, etc.

Several RELs have been proposed to describe licenses governing the terms and conditions of content access. In this field, the Open Digital Rights Language (ODRL) proposed by Renato Ianella and MPEG-21 REL based on the eXtensible rights Markup Language (XrML) [8] cover a prominent role. Both languages are powerful yet complex. MPEG-21 REL and ODRL are syntactically based on XML while structurally they both conform to the axiomatic principles of rights modelling first laid down in the Digital Property Rights Language (DPRL) [9].

2.1 ODRL

The ODRL is a proposed language for the DRM community for the standardisation of expressing rights information over content. The ODRL is intended to provide flexible and interoperable mechanisms to support transparent and innovative use of digital resources in publishing, distributing and consuming of electronic publications, music, audio, movies, digital images, learning objects, computer software and other creations in digital form. This is an XML-based usage grammar.

Using ODRL it is possible to specify, for a digital resource (music work, content, service, or software application), which is allowed to use that resource, the rights available to them and the terms, conditions or restrictions necessary to exercise those rights on the resource. The ODRL function is to express rights granted by some parties for specific resources and the conditions under which those rights apply.

ODRL is based on an extensible model for rights expressions, which involves three core entities and their relationships in a DRM license (see Figure 1):

- **Party** includes end users and Rights Holders. Party can be an entity such as the person, organisation, or device to whom rights are granted.
- **Right** includes permissions, which can then contain constraints, requirements, and conditions. Permissions are the actual usages or activities allowed over the assets (e.g. play, print, etc.) Constraints are limits to these permissions (e.g. print an e-book for a maximum of 3 times) Requirements are the obligations needed to exercise the permission. Conditions specify exceptions that, if they become true, expire the permissions and re-negotiation may be required.
- **Asset** includes any physical or digital content. They must be uniquely identified and may consist of many subparts and be in many different formats. Assets can also be non-tangible expressions of works and/or manifested in particular renditions.

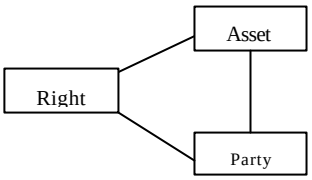

Figure 1. Core elements of ODRL

ODRL includes a data dictionary, which is formed by elements that defines permissions, rights, constraints, and requirements used in an ODRL license. All these elements form the basis of the language and can be extended by additional new elements.

For example, consider an e-book distributed to a consumer (Alice) that she can print 3 times. The ODRL license has a sentence that says that Alice is granted with the right to print the book for 3 times. In this case, Alice is a party, the book is an asset, print is a right, and "3 times" is a constraint included in the right element. Figure 2 shows this example.

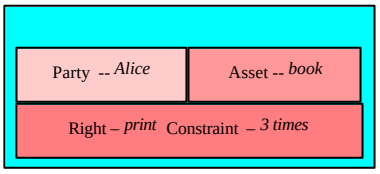

Figure 2. ODRL core elements example.

2.2 MPEG-21 REL

The REL from MPEG-21 is based on the XrML proposal. Using MPEG-21 REL it is possible to specify, for a digital resource (content, service, or software application), who is allowed to use that resource, the rights available to them and the terms, conditions or restrictions necessary to exercise those rights on the resource.

Part 5 of the MPEG-21 standard specifies the syntax and semantics of a Rights Expression Language.

MPEG-21 Rights Expression Language (REL) specifies the syntax and semantics of the language for issuing rights for Users to act on Digital Items, their Components, Fragments, and Containers.

MPEG-21 REL makes use of the Rights Data Dictionary [10], part 6 of the MPEG-21 standard, that comprises a set of clear, consistent, structured, integrated and uniquely identified terms. The structure of the RDD is designed to provide a set of well-defined terms for use in rights expressions.

At the heart of REL is the REL Core Schema whose elements and types define the core structural and validation semantics that comprises the essence of the specification. The REL Core Schema includes Core Principals, Core Rights, Core Resources and Core Conditions.

The core data model is enhanced by a number of so-called "Extensions" which add both functionality and applicability.

The most important concept in REL is the license that conceptually is a container of grants, each one of which conveys to a principal the sanction to exercise a right against a resource. The structure of a license is shown in Figure 3.

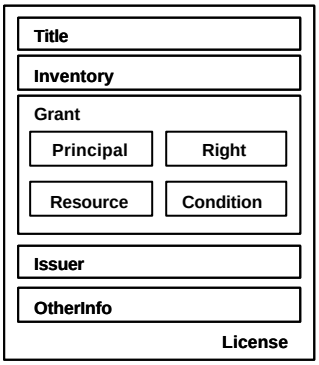

Figure 3. MPEG-21 REL license

The Title element provides a descriptive phrase about the License that is intended for human consumption in user interfaces. The Inventory element is used for defining variables within a License. The grant or grantGroup element expresses an assertion that some Principal may exercise some Right against some Resource, subject, possibly, to some Condition.

The grant or grantGroup is formed by the following four elements (see Figure 4):

- **Principal:** identifies an entity such as the person, organisation, or device to whom rights are granted. Each principal identifies exactly one party. Typically, this information has an associated authentication mechanism by which the principal can prove its identity.
- **Right**: specifies the activity or action that a principal can be granted to exercise against some resource.
- **Resource**: identifies an object which the principal can be granted a right. It can be a digital work, a service or a piece of information that can be owned by a principal. A Uniform Resource Identifier (URI) can be used to identify a resource.
- **Condition**: specifies one or more conditions that must be met before the right can be exercised. For example, a principal may need to pay a fee to exercise a right, a limit to the number of times, a time interval within which a right can be exercised, etc.

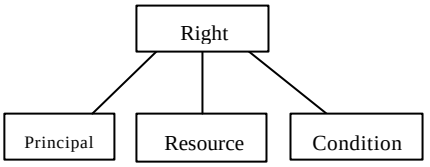

Figure 4. MPEG-21 REL core elements example.

The issuer element that represents the entity that issues the license may contain two pieces of information, a set of issuer-specific details about the circumstances under which he issues the license, and an identification of the issuer, possibly coupled with a digital signature for the license.

Finally, within the other information element, license issuers may place additional content as they find appropriate and convenient.

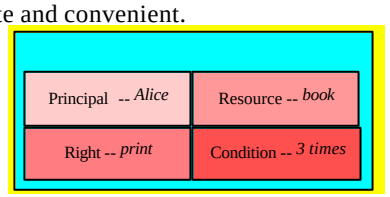

Figure 5. MPEG-21 REL example.

For example, we can consider the previous ODRL example, where an e-book is distributed to a consumer (Alice) that she can print 3 times. The MPEG-21 REL license has a sentence that says that Alice is granted with the right to print the book for 3 times. In this case, Alice is a principal, the book is a resource, print is a right, and "3 times" is a condition. In MPEG-21 REL the right-granting portion of this statement is called a grant and the entire statement is called a license. Figure 5 shows this example.

3. Intellectual Property Management and Protection

Currently, there is a lack of IPMP solutions to provide interoperability between devices and providers of content and services. Because of this fact, MPEG-21 is trying to provide a framework for the creation of new services that can be used to support new business models and that meet the needs of all members of the value chain. MPEG-21 IPMP has a very important role in the creation of these business models and must provide much more functionality than simply focusing on the content protection.

The MPEG-21 IPMP Components standard (Part 4) specifies components for IPMP applied to Digital Items to facilitate the exchange of governed and/or protected content between Peers. The MPEG-21 IPMP Components standard specifies the IPMP Digital Item Declaration Language (DIDL) that encapsulates and protects content, for example a DIDL document or part(s) thereof or asset(s), and associates appropriate identification and protection information with it. DIDL documents are specified in Part 2 of the MPEG-21 standard, Digital Item Declaration (DID), that provides an interoperable schema for declaring digital representation of works.

Moreover, MPEG-21 IPMP Components also describes, in a standardised way, information related to the IPMP Tools that protect the associated Contents, and to the licenses that govern them. The standardised IPMP info schema provides a "framework-level" description for IPMP information related to tools that protect resources or assets. It also addresses authentication of IPMP tools, and integrates rights expressions according to the Rights Data Dictionary and the Rights Expression Language.

4. OMA DRM REL and MPEG-21 REL

The Open Mobile Alliance (OMA) was formed in June 2002 by nearly 200 companies including the world's leading mobile operators, device and network suppliers, information technology companies and content and service providers. OMA specifications are the result of continuous work to define industry-wide interoperable mechanisms for developing applications and services that are deployed over wireless communication networks.

OMA DRM defines a DRM system to enable the consumption of digital content in a controlled manner, taking into account the special requirements and characteristics of the mobile domain. OMA DRM REL is defined as a mobile profile or subset of ODRL v1.1, and specifies the rights expression language used to describe mechanisms for expressing rights over DRM Content in an OMA DRM system.

There are two different versions of OMA DRM REL specification: OMA DRM REL specification v1.0 and OMA DRM REL specification v.2.0. Both specifications are defined with a Document Type Definition (DTD).

Security constitutes an important part of a DRM System, and OMA DRM REL v1.0 and, in a deeper way OMA DRM REL v2.0, provide the specification of the elements that are needed to get confidentiality , other security features, new rights and conditions.

4.1. OMA - based MPEG-21 REL v1.0

In this section, we propose an equivalent structure of the Rights Expression Language of OMA DRM REL v1.0, but defined as a subset of MPEG-21 REL, and not as a subset of ODRL (see figure 6).

The specification of OMA-based MPEG-21 REL v1.0. is defined with a DTD, and it could be considered a basic subset of OMA - based MPEG-21 REL v2.0. explained in the next section.

```
<!ELEMENT r:license ( (r:grantgroup|r:grant), r:otherinfo? )>
<!ELEMENT r:grantgroup (r:grant+)>
<!ELEMENT
  r:grant  ((mx:play|mx:execute|mx:print)?,
      r:digitalResource,  r:allConditions?)>

<!ELEMENT mx:play EMPTY>
<!ELEMENT mx:execute EMPTY>
<!ELEMENT mx:print EMPTY>

<!ELEMENT r:digitalResource (r:nonSecureIndirect) >
<!ELEMENT r:nonSecureIndirect EMPTY>
<!ATTLIST r:nonSecureIndirect URI CDATA #IMPLIED>

<!ELEMENT
       r:allConditions (sx:exerciseLimit?,
         validityInterval?, alidityIntervalDurationPattern?)>
<!ELEMENT sx:exerciseLimit (sx:count)>
<!ELEMENT sx:count (#PCDATA)>
<!ELEMENT r:validityInterval (r:notBefore?, r:notAfter?)>
<!ELEMENT r:notBefore (#PCDATA)>
<!ELEMENT r:notAfter (#PCDATA)>
<!ELEMENT sx:validityIntervalDurationPattern
(sx:duration)>
<!ELEMENT sx:duration (#PCDATA)>
<!ELEMENT r:otherinfo (version?,KeyValue?)>
<!ELEMENT version (#PCDATA)>
<!ELEMENT KeyValue (#PCDATA)>
```

Figure 6. OMA-based MPEG-21 REL DTD v1.0

4.2. OMA - based MPEG-21 REL DTD v2.0

In this section, we propose an equivalent structure of the Rights Expression Language of OMA DRM REL v2.0, but defined as a subset of MPEG-21 REL, and not as a subset of ODRL (see figures 7 and 8).

The specification of OMA-based MPEG-21 REL v2.0. is defined with a DTD, and it could be considered an extension of OMA - based MPEG-21 REL v1.0. explained in the previous section. This specification adds some relevant complexity over version 1.0. The main differences with respect to v1.0. are: inheritance model, new concepts to the security model that were missing in previous version and a data dictionary which is the result of a join of ODRL XML schema, ODRL Data Dictionary and a new OMA Data Dictionary.

```
<!ELEMENT r:license ((r:grantgroup | r:grant),
r:otherinfo?)>
<!ELEMENT r:grantgroup (r:grant+)>
<!ELEMENT r:grant
(r:keyHolder?,(mx:play| mx:execute | mx:print | inherit |
mx:move | mx:adapt | mx:execute)?, r:digitalResource,
r:allConditions?, mx:prohibitedAttributeChanges?,
r:keyHolder?)>
<!ATTLIST r:grant
        licensePartId CDATA #IMPLIED>
<!ELEMENT r:keyHolder (r:info)>
<!ELEMENT r:info (version?, uid?)>
<!ELEMENT mx:play EMPTY>
<!ELEMENT mx:execute EMPTY>
<!ELEMENT mx:print EMPTY>
<!ELEMENT mx:move EMPTY>
<!ELEMENT mx:adapt EMPTY>
<!ELEMENT inherit EMPTY>
<!ATTLIST inherit
        URI CDATA #IMPLIED>
<!ELEMENT mx:prohibitedAttributeChanges (set+)>
<!ELEMENT set EMPTY>
<!ATTLIST set
        definition CDATA #REQUIRED>
<!ELEMENT r:digitalResource (r:nonSecureIndirect)>
<!ELEMENT r:nonSecureIndirect EMPTY>
<!ATTLIST r:nonSecureIndirect
        URI CDATA #IMPLIED>
<!ELEMENT r:allConditions (sx:exerciseLimit?,
r:validityInterval?, sx:validityIntervalDurationPattern?,
mx:destination?, mx:validityTimeMetered?, mx:renderer?)>

<!ELEMENT mx:destination (r:keyHolder)>
<!ELEMENT mx:renderer (r:keyHolder)>
<!ELEMENT sx:exerciseLimit (sx:count)>
<!ELEMENT sx:count (#PCDATA)>
<!ELEMENT r:validityInterval (r:notBefore?,
r:notAfter?)>
```

Figure 7. OMA-based MPEG-21 REL DTD v2.0 part 1

```
<!ELEMENT r:otherinfo (version?, KeyValue?, uid*,
exerciseLimitDuration?, ((digest?, KeyInfo?) |
grantgroup))?>

<!ELEMENT version (#PCDATA)>

<!ELEMENT exerciseLimitDuration (#PCDATA)>
<!ELEMENT keyValue (#PCDATA)>
<!ELEMENT uid (#PCDATA)>

<!ELEMENT grantgroup (grant+)>
<!ELEMENT grant (digest?, KeyInfo?)>
<!ATTLIST grant
        licensePartIdRef CDATA #IMPLIED
>

<!ELEMENT digest (dsig:DigestMethod, dsig:DigestValue)>

<!ELEMENT dsig:DigestMethod (#PCDATA)>
<!ATTLIST dsig:DigestMethod
        Algorithm CDATA #FIXED
"http://www.w3.org/2000/09/xmldsig#sha1"
>

<!ELEMENT dsig:DigestValue (#PCDATA)>
<!ELEMENT KeyInfo (xenc:EncryptedKey?,
ds:RetrievalMethod?)>
<!ELEMENT xenc:EncryptedKey (ds:KeyInfo?,
xenc:EncryptionMethod, xenc:CipherData)>
<!ELEMENT xenc:EncryptionMethod (#PCDATA)>
<!ATTLIST xenc:EncryptionMethod
        Algorithm CDATA #FIXED
"http://www.w3.org/2001/04/xmlenc#kw-aes128"
>
<!ELEMENT xenc:CipherData (xenc:CipherValue)>
```

Figure 8. OMA-based MPEG-21 REL DTD v2.0 part 2

5. Interoperability between mobile profiles

As said before, ODRL and MPEG-21 REL have many syntactically an structurally similarities.

These RELs are widely used, so it is very important to permit interoperability between different systems that use them. They have the same objective and they start from the same base.

To transform an ODRL license into an MPEG-21 REL license, or vice versa, is equivalent to transform a XML document to another XML document, where the information they represent is the same one, but with a different XML structure.

This is only possible when both specifications convey the same semantics, as it is the case in our mapping from OMA DRM REL to MPEG-21 REL.

In order to obtain this transformation, XSL (Extensible Stylesheet Language) can be used [1]. XSLT applies transformation rules to the document source and, by changing the tree structure, produces a new document, such as another XML document. It can also amalgamate several documents into one, or even produce several documents starting from the same XML document.

If we consider the similarities between both languages, and the similarities between the previous equivalent DTDs (those shown in sections 4.1 and 4.2), it can be concluded that the interoperability between both languages is possible only for specific profiles, in this case mobile profiles. To achieve this interoperability or syntactical transformation, XSLT can be used.

6. Interoperability between MPEG-21 REL and OMA DRM REL v1.0

This section contains a table with the XML equivalences between the OMA ODRL profile and the OMA-based MPEG-21 REL subset, previously defined (see section 4.1). These equivalences will lead us to achieve interoperability between this MPEG-21 REL subset for the mobile domain and OMA DRM REL specification, doing a XSLT transformation.

OMA DRM REL v1.0 is fully supported by OMA DRM REL v2.0, specification that contains the version 1.0. A more precise explanation about REL elements used in the table 1 are given in the next section about version 2.

OMA ODRL	**OMA-based MPEG-21 REL**
<o-ex:rights>	<r:license>
<o-ex:context> <o-dd:version>1.0 </o-dd:version> </o-ex:context>	<r:otherInfo> <version>1.0 </version> </r:otherInfo>
<o-ex:asset> <o-ex:context> <o-dd:uid> cid:4567829547@foo.com </o-dd:uid> </o-ex:context> </o-ex:asset>	<r:digitalResource> <r:nonSecureIndirect URI='cid:4567829547@foo.com' /> </r:digitalResource>
<o-dd:display/>	<mx:play />
<o-dd:play/>	<mx:play />
<o-ex:permission> <o-dd:display> <o-ex:constraint> <o-dd:count> 1 </o-dd:count>	<r:allConditions> <sx:exerciseLimit> <sx:count>1</sx:count> </sx:exerciseLimit> </r:allConditions>
</o-ex:constraint> </o-dd:display> </o-ex:permission>	
<o-ex:asset> <o-ex:context> <o-dd:uid> cid:4567829547@foo.com </o-dd:uid> </o-ex:context> <ds:KeyInfo> <ds:KeyValue> vUEwr8LzEJoeiC+dgT1mgg== </ds:KeyValue> </ds:KeyInfo> </o-ex:asset>	<r:digitalResource> <r:nonSecureIndirect URI='cid:4567829547@foo.com' /> </r:digitalResource> ... <r:otherInfo> <KeyValue> vUEwr8LzEJoeiC+dgT1mgg== </KeyValue> </r:otherInfo>

Table 1. XML equivalences

7. Interoperability between MPEG-21 REL and OMA DRM REL v2.0

In this section, we introduce different tables with XML equivalences, between the OMA DRM REL v2.0 and the related MPEG-21 REL subset (see section 4.2). These equivalences will lead us to achieve also interoperability with XSLT transformation between this second MPEG-21 REL subset for the mobile domain and OMA DRM REL specification.

Different models are used to group the XML equivalences according to their functionality and license structure. The models used in this section are: Basic equivalences, Rights, Conditions, Security information association, Security and Inherit model.

In the first four models we are defining the elements that form the subset of MPEG-21 REL that fulfils OMA DRM REL v2.0 specification. The security model can be mapped to MPEG-21 REL by defining the corresponding elements in MPEG-21 <otherinfo> element or using the MPEG-21 IPMP Components specification. Finally, MPEG-21 has been extended to represent the OMA DRM <inherit> element.

7.1. Basic

The basic equivalences (see Table 2) constitutes the basis for licences and includes the necessary elements in any license. The OMA DRM REL <rights> and <asset> elements are represented with the MPEG 21 REL <license> and <digitalResource> elements. The OMA <context> element provides meta information about the rights, and is represented with the MPEG-21 <otherinfo> element.

OMA DRM REL v2.0	OMA-based MPEG-21 REL
<o-ex:rights>	<r:license>
<o-ex:context> <o-dd:version>2.0</o-dd:version> <o-dd:uid>RightsObjectID</o-dd:uid> </o-ex:context>	<r:otherinfo> <version>1.0 </version> <uid>RightsObjectID</uid> </r:otherinfo>
<o-ex:asset> <o-ex:context> <o-dd:uid>ContentID</o-dd:uid> </o-ex:context> </o-ex:asset>	<r:digitalResource> <r:nonSecureIndirect URI='ContentID' /> </r:digitalResource>

Table 2. Basic equivalences

7.2. Rights

This table 3 introduces the MPEG-21 REL rights equivalent to the rights specified in OMA DRM REL. The <display> and <play> elements are represented with the <play> element, the <export - move> element with the <move> element and the <export - copy> element with the <adapt> element and <prohibitedAttributeChanges> elements.

OMA DRM REL v2.0	OMA-based MPEG-21 REL
<o-dd:display/>	<mx:play />
<o-dd:play/>	<mx:play />
<o-dd:execute/>	<mx:execute />
<o-dd:print/>	<mx:print />
<oma-dd:export oma-dd:mode="move"> <o-ex:constraint> <oma-dd:system> <o-ex:context> <o-dd:version> 1.0 </o-dd:version> <o-dd:uid> XYZ </o-dd:uid> </o-ex:context> </oma-dd:system> </o-ex:constraint> </oma-dd:export>	<mx:move/> <r:digitalResource> <r:nonSecureIndirect URI="ContentID"/> </r:digitalResource> <r:allConditions> <mx:destination> <r:keyHolder> <r:info> <version>1.0</version> <uid>XYZ</uid> </r:info> </r:keyHolder> </mx:destination> </r:allConditions>
<oma-dd:export oma-dd:mode="copy"> <o-ex:constraint> <oma-dd:system> <o-ex:context> <o-dd:version> 1.0 </o-dd:version>	<mx:adapt/> <r:digitalResource> <r:nonSecureIndirect URI="ContentID1"/> </r:digitalResource> <mx:prohibitedAttributeChanges> <set definition=
<o-dd:uid> XYZ </o-dd:uid> </o-ex:context> </oma-dd:system> </o-ex:constraint> </oma-dd:export>	"urn:mpeg:mpeg21:2003:01-RDD-NS:2346"/> <set definition= "urn:mpeg:mpeg21:2003:01-RDD-NS:2347"/> </mx:prohibitedAttributeChanges> <r:keyHolder> <version>1.0</version> <uid>XYZ</uid> </r:keyHolder>

Table 3. Rights

7.3.Time conditions

This table 4 introduces the MPEG-21 REL time conditions equivalent to the ones specified in OMA DRM REL. The <datetime> element represented in MPEG-21 REL with the <validityInterval> element specifies an interval of time within which a right can be exercised. The <interval> represented in MPEG-21 REL with the <validityIntervalDurationPattern> element specifies a period of time within which a right can be exercised. Finally, the <accumulated> element represented in MPEG-21 REL with the <validityTimeMetered> specifies the maximum period of metered usage time during which the rights can be exercised.

OMA DRM REL v2.0	OMA-based MPEG-21 REL
<o-ex:constraint> <o-dd:datetime> <o-dd:start>... </o-dd:start> <o-dd:end>... </o-dd:end> </o-dd:datetime> </o-ex:constraint>	<r:allConditions> <r:validityInterval> <r:notBefore>...</r:notBefore> <r:notAfter>...</r:notAfter> </r:validityInterval> </r:allConditions>
<o-ex:constraint> <o-dd:interval> </o-dd:interval> </o-ex:constraint>	<r:allConditions> <sx:validityIntervalDurationPattern> <sx:duration> </sx:duration> </sx:validityIntervalDurationPattern> </r:allConditions>
<o-ex:constraint> <o-dd:accumulated> PT10H </ o-dd:accumulated> </o-ex:constraint>	<r:allConditions> <sx:validityTimeMetered> <sx:duration>PT10H</sx:duration> </sx:validityTimeMetered> </r:allConditions>

Table 4. Time conditions

7.4. More conditions

In the table 5 we introduce the rest of MPEG-21 REL conditions considered in the mobile subset we are

defining equivalent to the ones specified in OMA DRM REL. The <count> element represented in MPEG-21 REL with the <exerciseLimit> element specifies the number of allowed exercises. The <timed-count> element specify the number of times a permission may be granted over an asset or resource, with the addition of an optional timer attribute. This timer attribute specifies the number of seconds after which the count state can be reduced. As the timer attribute is not specified in MPEG-21 REL, we have defined the <exerciseLimitTime>, that consist of <count> and <duration> elements. The <individual> represented in MPEG-21 REL with the <keyHolder> element specifies the individual to which content is bound. The <system> represented in MPEG-21 REL with the <renderer> element specifies the target system to which DRM Content and Rights Objects can be exported.

OMA DRM REL v2.0	OMA-based MPEG-21 REL
<o-ex:constraint> <o-dd:count > 1 </o-dd count> </o-ex:constraint>	<sx:exerciseLimit> <sx:count>1</sx:count> </sx:exerciseLimit>
<o-ex:constraint> <o-dd:timed-count timer="30">1 </o-dd:timed-count> </o-ex:constraint>	<r:otherinfo> <exerciseLimitTime> <sx:count>1</sx:count> <sx:duration>30 </ sx:duration> </exerciseLimit> </r :otherinfo>
	<r:grant licensePartId="Asset-1"> <r:allConditions> <sx:exerciseLimit> <sx:count>1</sx:count> </sx:exerciseLimit> </r:allConditions> </r:grant licensePartId="Asset-1"> <r:otherinfo> <grant licensePartIdRef="Asset-1"> <exerciseLimitDuration> 30 </exerciseLimitDuration> </grant> </r:otherinfo>
	<sx:exerciseLimit> <r:serviceReference licensePartIdRef="externalService"/> <sx:count>1</sx:count> </sx:exerciseLimit>
<o-ex:constraint> <o-dd:individual> <o-ex:context> <odd:uid> XYZ </odd:uid> </o-ex:context> </o-dd: individual> </o-ex:constraint>	<r:grant> <r:keyHolder> <r:info> <uid>XYZ</uid> </r:info> </r:keyHolder> </r:grant>
<o-ex:constraint> <oma-dd:system>	<mx:renderer> <r:keyHolder>
<o-ex:context> <odd:uid> XYZ </odd:uid> </o-ex:context> </oma-dd system> </o-ex:constraint>	<r:info> <uid>XYZ</uid> </r:info> </r:keyHolder> </mx:renderer>

Table 5. More conditions

7.5. Security

Security constitutes an important part of a DRM system. OMA DRM REL v 2.0 provides confidentiality for the CEK (Content Encryption Key) of Rights Objects, integrity of the association between Rights Objects and DRM Content and Rights Object integrity and authenticity.

In MPEG-21 REL the security issue is not considered. To provide the OMA DRM REL security functionalities in MPEG-21 REL, we have considered two approaches. The first one is to define this security information within the MPEG-21 REL <otherinfo> element, as defined in the table 6. The second one is to consider MPEG-21 IPMP Components specification, as explained in section 8.

OMA DRM REL v2.0	OMA-based MPEG-21 REL
<o-ex:agreement> <o-ex:digest> <ds:DigestMethod Algorithm="..."/> <ds:DigestValue> DCFHash </ds:DigestValue> </o-ex:digest> </o-ex:agreement>	<r:otherinfo> <digest> <dsig:DigestMethod Algorithm="..."/> <dsig:DigestValue> DCFHash </dsig:DigestValue> </digest> </r:otherinfo>
<o-ex:agreement> <ds:KeyInfo> <xenc:EncryptedKey> <xenc:EncryptionMethod Algorithm="..."/> <xenc:CipherData> <xenc:CipherValue> EncryptedCEK </xenc:CipherValue> </xenc:CipherData> </xenc:EncryptedKey> <ds:RetrievalMethod URI="REKRe"/> </ds:KeyInfo> </o-ex:agreement>	<r:otherinfo> <KeyInfo> <xenc:EncryptedKey> <xenc:EncryptionMethod Algorithm="..."/> <xenc:CipherData> <xenc:CipherValue> EncryptedCEK </xenc:CipherValue> </xenc:CipherData> </xenc:EncryptedKey> <ds:RetrievalMethod URI="REKRe"/> </KeyInfo> </r:otherinfo>

Table 6. Security

7.6. Security information association

The table 7 explains how to associate security information to different assets or resources in the same license. The MPEG-21 REL <otherinfo> element

includes a <grant> element with the security information and a reference to the grant related.

OMA DRM REL v2.0	OMA-based MPEG-21 REL
<o-ex:agreement> *<o-ex:asset o-ex:id="A-1">* *<o-ex:digest>...</o-ex:digest>* *<ds:KeyInfo>..</ds:KeyInfo>* *</o-ex:asset>* *<o-ex:asset o-ex:id="A-2">* *<o-ex:digest>...</o-ex:digest>* *<ds:KeyInfo>...</ds:KeyInfo>* *</o-ex:asset>* *</o-ex:agreement>*	*<otherinfo>* *<r:grantgroup>* *<r:grant licensePartId="A-1">* *</r:grant>* *<r:grant licensePartId="A-2">* *</r:grant>* *<r:otherinfo>* *<grant licensePartIdRef="A-1">* *<digest>...</digest>* *<KeyInfo>...</KeyInfo>* *</grant>* *<grant licensePartIdRef="A-2">* *<digest>...</digest>* *<KeyInfo>...</KeyInfo>* *</grant>* *</r:grantgroup>* *</r:otherinfo>*

Table 7. Security information association

7.7. Inherit

The OMA DRM REL inherit model is not considered in MPEG-21 REL, therefore MPEG-21 REL has been extended with a new <inherit> right, as we show in the table 8. A License called parent license defines Permissions and Constraints for DRM Content which can be inherited by a new license called child License. In the child license we only include a reference to the parent license, and then the child license inherits permissions and constraints from the parent license.

OMA DRM REL v2.0	OMA-based MPEG-21 REL
<o-ex:asset> *<o-ex:inherit>* *<o-ex:context>* *<o-dd:uid>Subs</o-dd:uid>* *</o-ex:context>* *</o-ex:inherit>* *<o-ex:asset>*	*<r:grant>* *<inherit URI="Subs"/>* *</r:grant>*

Table 8. Inherit

8. Protection of multimedia content

OMA and MPEG-21 standards have considered a different approach in the specification of protection and governance information and their association with digital content. OMA DRM REL v2.0 includes protection information within the licenses, while in the MPEG-21 standard the protection information and the mechanisms to associate it, together with licenses, to protected and governed content is defined in IPMP Components, Part 4 of the MPEG-21 standard.

To achieve interoperability between OMA and MPEG-21 standard we have considered two approaches. The first one, presented in section 7, is to define a mobile profile for MPEG-21 REL and RDD defining a subset of rights, resources and conditions according to OMA DRM REL v2.0 specification, but extending it by defining the appropriate elements (see section 7.5) for the protection information and DRM content association integrity. The second approach is to consider MPEG-21 IPMP Components specification to describe protection information and restrict MPEG-21 REL and RDD parts for mobile applications. Note that in this approach we only have to consider the extension done in MPEG-21 REL for the inheritance model as specified in section 7.7 to achieve interoperability with OMA DRM REL v2.0 specifications.

In this section we present how protection information is described and associated to content, using MPEG-21 IPMP technologies. On the other hand, the licenses are generated according to the profile defined for MPEG-21 REL in section 7 without considering the extension proposed for protection information in security section.

```
<didl:DIDL>
 <didl:Item>
  <didl:Component>
   <didl:Resource mimeType="application/ipmp">
    <ipmpdidl:ProtectedAsset mimeType="video/mpeg">
     <ipmpdidl:Info>
      <IPMPInfoDescriptor>
       <Tool>
          Protection tools information
       </Tool>
       <RightsDescriptor>
        <License>
         <r:license>
          <r:grant>
           <inherit URI="SubscriptionGUID"/>
           <r:digitalResource>
            <r:nonSecureIndirect URI="ContentID"/>
           </r:digitalResource>
          </r:grant>
          <r:otherinfo>
           <version>2.0</version>
           <uid>RightsObjectID</uid>
          </r:otherinfo>
         </r:license>
        </License>
       </RightsDescriptor>
      </ipmpdidl:Info>
     <ipmpdidl:Contents ref="ContentID"/>
    </ipmpdidl:ProtectedAsset>
   </didl:Resource>
  </didl:Component>
 </didl:Item>
</didl:DIDL>
```

Figure 9. Protected and governed asset

Figure 9 shows how protection and governance information is described and associated to digital content, using IPMP and MPEG-21 REL technologies equivalent to OMA DRM REL v2.0. Specifically, protection tools are described using the MPEG-21 IPMP Information Descriptor schema and governance information using the subset of MPEG-21 REL defined for the mobile profile. Finally, IPMP-DIDL schema is used to associate this information with the correspondent asset.

Main difference of the two approaches considered is the information expressed in the licenses. In the first one, licenses contain information related to the rights and conditions of use of digital content and content protection information, while in the second one protection information is not described within licenses. Figure 10 shows how an encryption tool is described in the second approach presented using MPEG-21 IPMP Components specification. The "Tool" element contains relevant information of the tool that will be used to decrypt the content, as its unique identifier, the remote location from where it can be retrieved, and its initialization settings where two different types of data are placed. On one hand, the "InitializationData" that contains the key (CEK) for decrypting the content using the tool previously described, this key is also encrypted (EncryptedCEK). On the other hand, the information of the tool that will be used to decrypt this key (CEK) and a reference to the key used to encrypt the CEK.

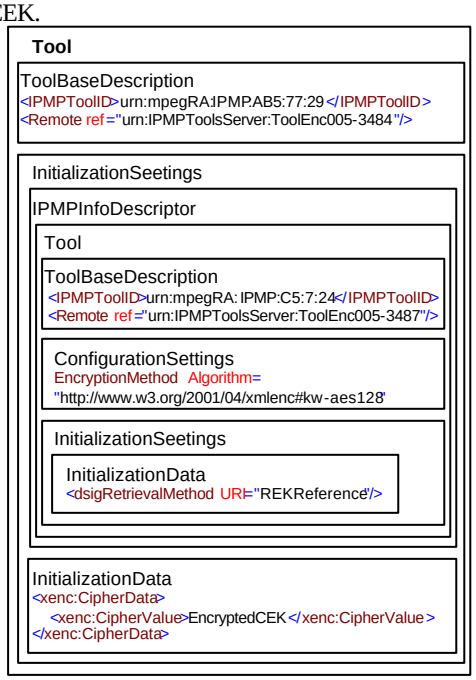

Figure 10. Encryption tool description example

9. Associated tools

In order to validate our proposal, we have adapted some of our previous tools [11], already contributed as MPEG-21 Reference Software [12], in order to work with this subset in both cases, OMA ODRL and MPEG-21 REL.

9.1. DMAG checker

The DMAG Checker (DC) is an application that syntactically validates a REL license, and subsets of them as the profiles proposed in this paper, against the DTD or XML Schema used by the license.

This software has been developed in Java. It can run on MS-Windows and Linux platforms. The parser used in the implementation is the Xerces parser. The output of the DC is a message reporting if the license is syntactically valid or not, according to the DTD or XML Schema specified within the license. If the license is not valid, the DC informs about the reasons why.

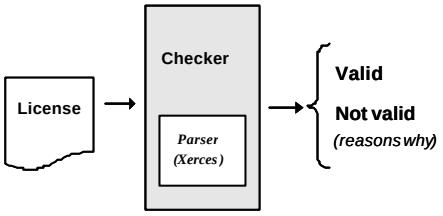

Figure 11. DMAG Checker

9.2. DMAG License Creator for mobile profiles

The DMAG License Creator for mobile profiles (subsets specified in this paper) is a software implementation that creates OMA – based MPEG-21 REL licenses equivalent to the OMA DRM v2.0 ones, and OMA DRM v2.0 licenses. This software has been developed in Java. It can run on MS-Windows and Linux platforms.

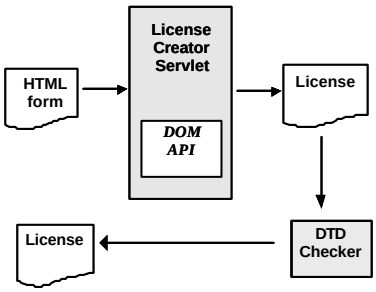

Figure 12. DMAG License Creator

9.3. DMAG License Translator

In order to implement a license translator for the mobile profile presented in this work, we have developed utilities to transform OMA – based MPEG-21 REL v1.0 and v2.0 licenses to OMA DRM REL v1.0 and v2.0 and in the reverse direction. These utilities have been developed using XSLT and permit to do a syntactical translation between the mobile profiles presented.

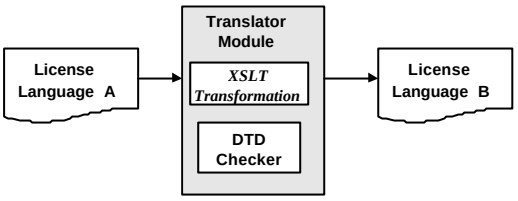

Figure 13. DMAG License Translator

10. Conclusions and further work

This paper has shown how interoperability and translation of licenses among different RELs (Rights Expression Languages) can be achieved. We have presented different possible solutions and tools to achieve interoperability among different versions of OMA DRM REL and MPEG-21 REL by defining subsets or profiles of MPEG-21 REL that provide the same functionalities as the OMA DRM REL, which is a mobile profile of ODRL. Tools to create and check licenses in a mobile profile have been introduced.

Furthermore, as the MPEG-21 REL standard specification does not provide all functionalities required by OMA, we have proposed to extend it and used MPEG-21 IPMP to fulfil security requirements.

However, the purpose of this paper has not been to define a formal mobile profile, since this should rather be an initiative from the interested industry. On the contrary, we are proposing a possible approach for the specification, and further implementation, of MPEG-21 subsets able to interoperate with other RELs.

Currently, we are working to extend the capabilities of the tools. The main objective of our future work is to expand the scope of this set of tools (generators and converters) to permit that every system could work in MPEG-21 REL or ODRL without distinction, transparently to the user.

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