Translation between XML-based rights expressions using UML and relational models

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Abstract

Digital Rights Management (DRM) systems interoperability is needed in order to be able to support different business models on different distribution channels. There are several steps to be taken for providing interoperability. We have decided to take as a first step the translation of rights expressions from language to language. This translation will allow cross content consumption between different DRM systems and devices, permitting to users to buy a content governed with rights expressions written in one language and supported by a DRM system and consume it in a different DRM system supporting a different language.

1. Introduction

The work presented is a work in progress in the area of digital rights management interoperability. Several steps have to be taken to achieve the desired interoperability, but we have started by translating rights expression used in different DRM systems.

Some work has been already done in this area by other members of our research group [1], [2] and [3], where Extensible Style Sheet Transformations (XSLT) [4] were used to translate from licenses expressed in one XML-based language to another, but we are going to propose a different approach in this paper, based on the use of high-level modelling schemas, like Unified Modelling Language (UML) [5] and Entity-Relationship (ER) [6].

The rest of the paper is organised as follows. First, we briefly introduce the right expression languages we are going to use to perform the translations. They are MPEG-21 REL [7] and OMA DRM REL [8]. Next, we present the different modelling we have implemented for these languages using UML and ER diagrams. Then, we propose two different approaches for translating licenses and finally, we present some conclusions and future work.

2. Rights Expression Languages

Rights expression languages (RELs) have been proposed to express rights and conditions of use of digital content. Rights expression languages can be used for example to describe an agreement between a content provider and a distributor, or between a distributor and an end user, or can be used to express the copyright associated to a given digital content such as an album or a piece of music, by specifying under which conditions the user is allowed to exercise a right.

The most relevant ones are MPEG-21 REL [7] and OMA DRM REL [8], which is based on ODRL [9] and defined by Open Mobile Alliance (OMA) [10]. All of them are syntactically based on XML.

The rest of the section briefly describes the languages selected for performing translations between them, MPEG-21 REL and OMA DRM REL.

2.1. MPEG-21 Rights Expression Language

MPEG-21 REL specifies the syntax and semantics for issuing rights for users to act on multimedia content. One important concept in REL is the License. A License is a container of grants that are formed by a principal that has the permission to exercise a right against a resource under some conditions that must be previously fulfilled. Figure 1 shows the structure of a REL License.

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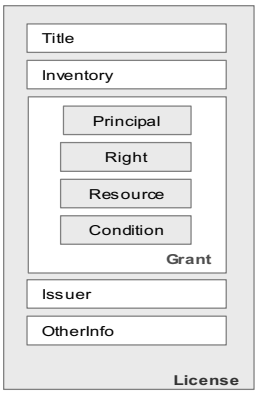

Figure 1: MPEG-21 REL license

Inside a REL license, the most important element is the Grant, which expresses that some Principal may exercise some Right against some Resource, subject, possibly, to some Condition. A Grant is an XML structure that is formed by four elements:

- Principal represents the unique identification of an entity involved in the granting or exercising of Rights.
- Right specifies an action or activity that a Principal may perform on, or using, some associated Resource.
- Resource represents the object against which the Principal of a Grant has the Right to perform.
- Condition represents grammatical terms, conditions and obligations that a Principal must satisfy before it may take advantage of an authorisation conveyed to it in a Grant.

2.2. OMA DRM Rights Expression Language

OMA [10] has developed OMA DRM, its digital rights management architecture to provide protection of content inside the mobile environment. They have also defined a rights expression language, OMA DRM REL [8], based on ODRL [9]. It is currently in its version 2. Using OMA DRM REL it is possible to express rights over an asset (a content in the OMA context) defining permissions and restrictions on its usage.

Although ODRL permits the creation of licenses with a structure very similar to MPEG-21 REL ones, the subset defined by OMA DRM REL is more limited. Figure 2 shows the basic structure of an ODRL license.

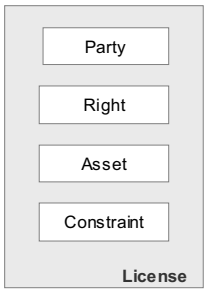

Figure 2: ODRL license

One of the limitations imposed by OMA DRM REL licenses are that they do not define the party element, as it is implicit to the user of the mobile device. Moreover, the rights are a subset of the ones in MPEG-21 REL.

3. Expressing XML Rights Expressions using UML

The first work done was to express both languages in an abstract UML [5] class diagram. The reason for creating these diagrams was that we need a solution to manipulate rights expressions in a software development project. The XML format is very readable and human comprehensive but is not very functional when you need to interact with it. So, the solution was to create different class diagrams for each Right Expression Language. In MPEG-21 REL we had to represent a subset, because the whole language is almost untreatable. OMA DRM REL is just a profile of ODRL.

3.1. MPEG-21 REL

We propose a simple but scalable solution for expressing licenses into an UML class diagram. This structure will simplify moving from one REL language to another expressing as many conditions as we want and also adding new conditions, if they appear.

All MPEG-21 REL Licenses can be represented using this model once parsed properly. With this model we are no restricting the syntactic structure of the licenses, but we need to transform them in a common format in order to facilitate searches.

Figure 3 shows the UML class diagram that we are proposing for representing the licenses.

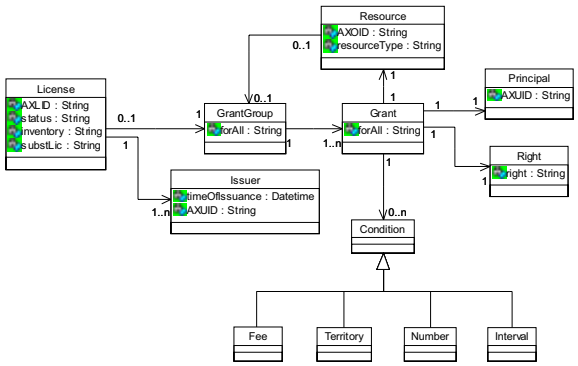

Figure 3: MPEG-21 REL UML Class Diagram

Each license can have a LicID element that contains a unique identifier for the license, there is also an issuer element and a *GrantGroup*. A status element contains the status of the license, e.g. revoked, a substLic element that contains the license that replaces the revoked one and an inventory element (that contains the variables defined in the license that can be referenced within it).

Each *GrantGroup* contains a set of *Grants* and the forAll element where the variables or patterns are defined within this *GrantGroup* are placed.

Each *Grant* contains the information of the right granted, the resource, the principal and an optional set of conditions related to that right, and the forAll element where the variables or patterns defined within this grant are placed.

In addition, we have to realise that a resource can be a *GrantGroup* (for the case of Distributor Licenses).

3.2. OMA DRM REL

As we did for the MPEG-21 REL, we have done a solution for the OMA licenses that let us to fill out all the possibilities that can be expressed by the language. For instance, the unique part of the standard that we are not supporting is the digital signature of the license, which goes on the digest element.

Figure 4 describes the UML class diagram representing the OMA licenses.

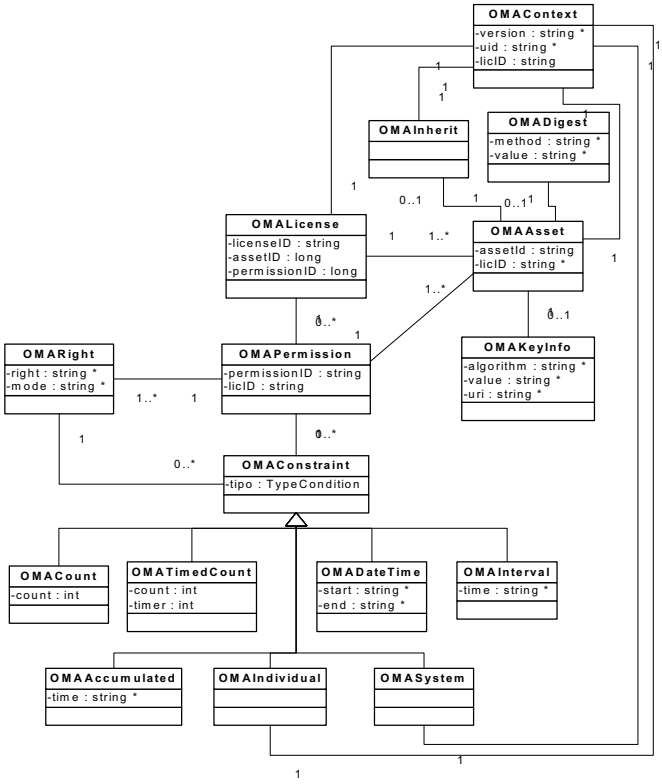

Figure 4: OMA DRM REL UML Class Diagram

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Each *OMALicense* is defined by a licenseID, that is an unique identifier for it, a *OMAContext* element, that expresses the uid and the version of the standard that have been used to create the license, and two more vectors containing the *OMAAssets* and *OMAPermissions*. Note that, opposite to MPEG-21, the *OMAAssets* (resources) and the *OMAPermissions* (constraints and rights) are stored separately because that is the way the license will represent it.

The *OMAAsset* stores all the information about the *OMAContext* (the real name and its version), the *OMADigest* (created at the end if you want the license to be signed), the *OMAInherit* information, if the license derives from another one, and the *OMAKey Information*, which is represented by an algorithm and a value.

The *OMAPermission* is the relation of one or more assets with one or more rights. The *OMAPermission* can have a set of constraints that applies to all the rights, and each right can also have a set of constraints that only affects itself.

We have also define all the *OMAConstraints* that can be represent with that Right Expression Language as Count, Timed Count, Date Time, Interval, Accumulated, Individual and System.

We are currently representing licenses that follow the version 2.0 of the OMA standard [8].

4. Expressing XML Rights Expressions using relational model

Persistency is not a problem in any of the right expression languages used. Transforming from XML to the equivalent object model based on the class diagram, or vice versa, is not an expensive work. So it can be always in XML format. The problem appears when you have to authorise (verify that somebody can exercise a right) and you have a very large number of licenses. For authorising, you must perform not trivial searches over the licenses, and it is not always possible to store them in memory (like an object model) all the licenses that you have created. This is the principal reason to create also an Entity Relationship Model to store the licenses. Because, with an adequate diagram and a good database manager, this searches can be performed quickly and efficiently.

4.1. MPEG-21 REL

We propose a simple but scalable solution for expressing licenses into the ER diagrams.

The approach we have followed is to impose a common structure for licenses in order to simplify the parsing from the XML-based license into the ER structure.

To represent the content of a license in an Entity-Relationship diagram, we have to focus on the relations with a multiplicity 0..n. These relations show us the number of different tables that we need to store the represented information. The relations with a multiplicity of 1 – 1 can be stored always in the same table.

Figure 5 shows how to create the different tables to store the license information. This solution provides the model for storing End-user Licenses, and also for storing Distributor Licenses.

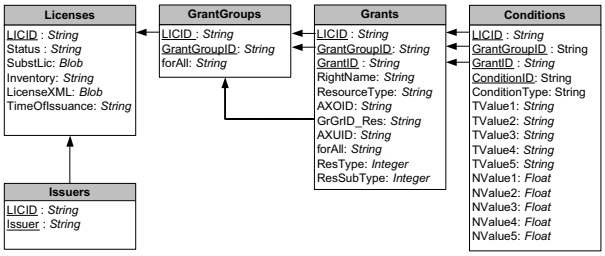

Figure 5: MPEG-21 REL ER Diagram

For expressing the different types of conditions we can have, we have defined the following information:

- ConditionType: It indicates which kind of condition we are expressing.
- Five Tvalue fields and two NValue fields (more can be added if desired), whose values depend on the conditionType. TValue fields represent textual information and NValue fields represent numerical information.

Using this structure we can easily define new conditions and implement support classes in the corresponding programming language depending on the condition.

We can also make complex queries over the defined ER diagram, only asking for different ConditionType, TvalueX and NvalueX.

Other possible approach for expressing conditions could have been to define a different table for each condition. We have discarded this approach, as conditions expressed in MPEG-21 REL have a lot of different possible and optional values, and making queries over such a structure could be even more complex than using only one table or the original XML file.

4.2. OMA DRM REL

As happened in the MPEG-21 REL solution, we have designed an ER structure, basing it in the multiplicity

of the elements involving these licenses, specially the assets and the permissions.

Figure 6 represents the structure that defines our solution for storing OMA DRM licenses in a scalable and efficient way.

As in the static model representation, we have separated the assets and the permissions in two different tables, as they do not have a 1 – 1 multiplicity. And for that reason we have got to add an extra table to store the relation of both elements.

For each asset we store only the values that are useful to do the authorisation process. They involve its context and the Key Information.

If the permission has a specific right, we store it in two different tables, as happens in the static model. The first one will only contain the right information, and the second one will store the constraints values too. In the other case, we only need to store the constraint type and its values in a separated table.

With this ER structure, we are able to store all the different ways in which licenses can be defined, and make it easier to perform the authentication and expand the model if the standard grows up in the future.

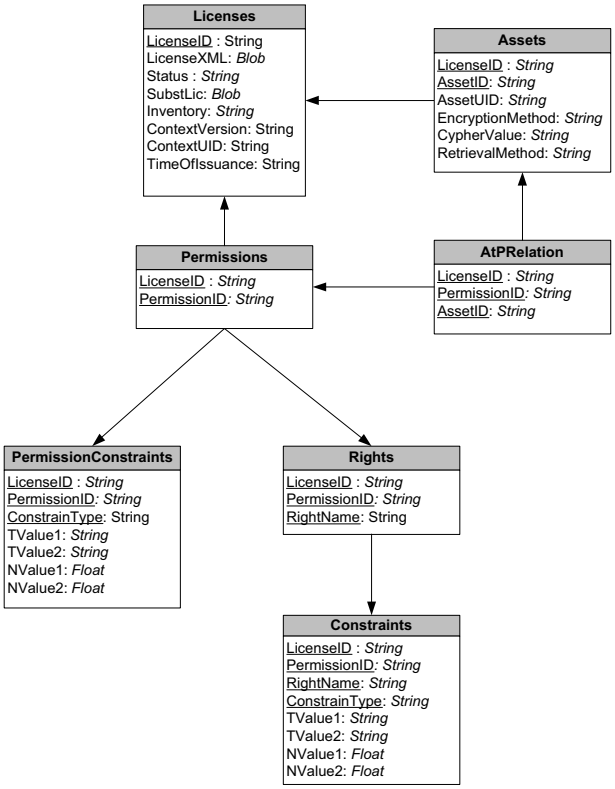

Figure 6: OMA DRM REL ER Diagram

5. Translation of rights expressions

Our first approach to the transformation of licenses form MPEG-21 REL to OMA and the other way around was to use XSLT (Style Sheets) [4]. Using this technique the structure of the licenses being transformed is very limited and restricted [2] and [3]. So we tried to do it in a different way, taking advantage of the UML and the entity relationship model to define two different alternatives to solve the problem.

5.1. Based on UML

OMA DRM and MPEG-21 REL express a license format, nevertheless the structure of these two kind of licenses is quite different. So it is not possible to use a

syntactic approach to perform the transformation but a semantic one based on the UML model.

The *License* class in the MPEG-21 diagram is equivalent to *OMALicense* class, and it is the object that holds the relationship of the model.

Another similarity is found at the *Condition* and *OMAConstraint* classes, which can be translated directly.

The critical point is that in MPEG-21 each *Grant* stores information about one right, one resource, one right holder and the conditions of this relationship. On the other hand OMA DRM stores all that information in different classes with different relationships (*OMAAsset*, *OMAPermission* and *OMARight*).

In order to translate the OMA DRM to MPEG-21 REL model, we have to generate a *Grant* for each relation that involves one *OMAAsset* with one *OMAPermission* and one *OMARight*. Moreover, we have to take into account that a set of *OMAConstraints* can affect one specific *OMARight* or the *OMAPermission* (that involves all the rights related with it).

Note that exist some elements in both languages that cannot be exactly translated and which have to be transformed not in the syntactic way but semantic (For example the TimedCount Constraint from OMA, or the adapt Right from MPEG-21).

If you want to translate from MPEG-21 REL to OMA DRM, you have to take care about the number of *OMAPermissions* that would be generated. To do that you have to group the *Grants* by the applied set of Conditions, in order to generate the minimum number of *OMAPermissions* and *OMARights*.

5.2. Based on a relational model

The other way to translate the licenses from one language to the other is to use the Relational model. In this case, we can use SQL sentences like selects and inserts to perform the transformations.

To transform from OMA DRM ER model to the MPEG-21 one you can use two intermediate tables, which contains both the grants and the conditions table. These two intermediate tables can be fulfilled with a complex select that involves the join of Permissions, Assets, and Rights tables on OMA DRM ER model. And these two intermediate tables can be directly transformed to the Grants and Conditions tables of the MPEG-21 ER model.

To transform the information from the MPEG-21 ER model to the OMA DRM one, we cannot grant that the resulting OMA license has the optimal structure. This is because every Grant in the MPEG-21 will be translated to a Permission with only one asset and one right.

In the case we want to obtain the optimal OMA license from the MPEG-21 one, we must find which Grants could belong to the same Permission. These ones would have the same set of rights with the same set of conditions for every right for a set of resources. This cannot be done using only SQL sentences, and requires a quite complex algorithm. Because of that we prefer to use the UML model to try to perform this transformation.

6. Comparison between XSLT and UML and relational model approach

The limitations of the XSLT solution is that we have to define a rule for each element inside the license. This is quite complex, as there are a lot of elements in the XML license, both in OMA DRM REL and MPEG-21 REL.

On the other hand, the definition of the UML class model allows an easier addition of conditions, by means of inheritance. We also make use of relational model fields to leave some elements as they are in the XML license (we apply here a hybrid approach).

If a massive translation of licenses is needed, XSLT approach is unmanageable, as we have only tested this solution with very simple licenses and the performance is not very good, so, if we use more complex structures, XSLT solution cannot be applied. Moreover, UML and ER models are not only used for translation. They allow other operations over licenses, like authorisation of user actions against the license chain and verification of license creation that are speeded up by using these models.

7. Conclusions and future work

DRM interoperability is needed in order to be able to support different business models on different distribution channels.

Several actions have to be taken in order to achieve the desired interoperability, but a first step is to translate rights expressions, specifically licenses from MPEG-21 REL and OMA DRM REL and the other way around. An initial approach was to use syntactical transformations using XSLT [4] for transforming from a license expressed in one language to another, but there were some limitations. We have presented a different approach here, based on high-level modelling schemas like UML and Entity Relationship (ER). Using the approach presented will allow speeding up and complicating possible translations between rights expressions.

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