

Profiling MPEG Rights Expression Language: Concept, Approach and Applications

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1 Introduction

The MPEG Rights Expression Language (REL) [1] is an upcoming ISO standard developed by MPEG. It defines a machine readable, XML-based language for expressing rights. In the media distribution context, content owners can use the MPEG REL to specify how content can be used and distributed throughout the value chain from content packagers, via content distributors, to content consumers. An REL for creating precise, reliable, and secure licenses for content is an essential component of any effective and scalable end-to-end digital rights management (DRM) system.

The MPEG REL is designed to be domain-agnostic and comprehensive. It is also very flexible and adaptive to the specific scope and requirements of applications within a particular domain. Specifically, the language provides extension and profile mechanisms for these purposes.

The main focus of this paper is to provide a guide, tutorial, and reference for developing MPEG REL profiles. In simple terms, a profile is a subset of the base specification, and it may incorporate additional syntactic, semantic, and processing restrictions, subject to maintaining compliance to the base specification.

This paper begins with a brief introduction of the MPEG REL for the benefit of those unfamiliar with it followed by a discussion of the abstract concepts and general principles of profiles of any XML-based specification. Then, this paper presents a detailed case study of creating an example profile of the MPEG REL for the mobile domain. The case study covers collecting and analyzing requirements and use cases for present-day mobile DRM systems, specifying and presenting the profile to satisfy these requirements, and validating the profile with example REL licenses for the mobile use cases.

2 MPEG REL

The MPEG REL [1] is an XML-based language for specifying rights and conditions to govern the use and distribution of digital content as well as access to services. This section provides a brief overview of the MPEG REL data model and the structure of the language.

2.1 REL Data Model

Using the MPEG REL, anyone owning or distributing digital resources can identify principals (such as users, groups, devices, and systems) allowed to use those resources, the rights available to those principals, and the terms and conditions under which those rights may be exercised.

The following diagram illustrates the seven basic MPEG REL elements used to encapsulate this information and their inter-relationships. For information on additional elements such as variables and delegation control, see [1].

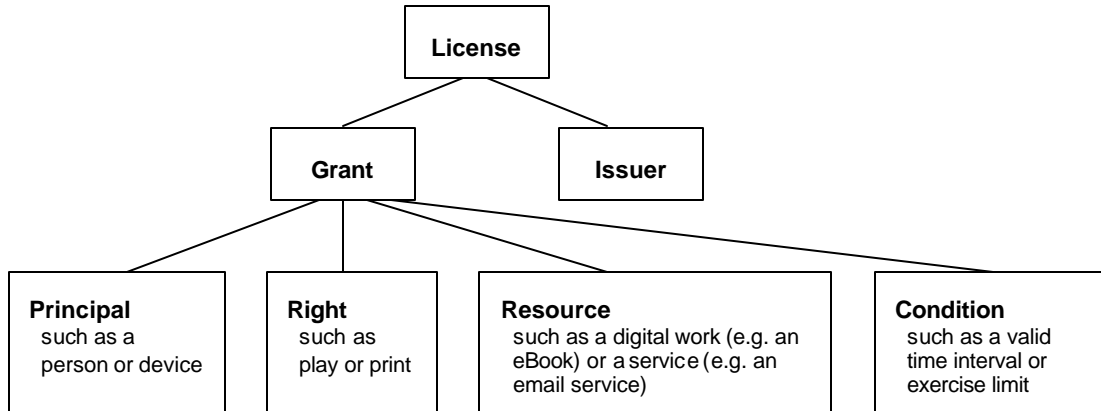


Figure 1 : REL data model

A simple REL license looks like the following in its skeleton form:

```

license
  grant
    Alice
    play
    aSong.mp3
    for 3 weeks
  issuer
    PDQ Records
  
```

Figure 2: Example REL license

In this example, a principal (Alice) has been granted the right to play a resource (a song) under the condition that she can only play it for 3 weeks. This right is conveyed under the authority of the license issuer (PDQ Records).

The license shown above provides only a simple illustration of the MPEG REL data model. It makes no attempt to fully illustrate the flexibility and expressiveness of the language. In fact, the MPEG REL can be used to create licenses that address a wide variety of business models. A few examples of the types of licenses that the MPEG REL can express include usage licenses, offers, distribution licenses (both single- and multi-tier), and certificates. Section 6 provides examples of complete usage licenses expressed in the MPEG REL that are appropriate to the mobile domain.

2.2 REL Structure

The MPEG REL is designed to be extensible and is itself specified in extensions. Its syntax is described and defined using the XML Schema and Namespace Recommendations by W3C [3, 4], which enables the MPEG REL to offer a high degree of richness and flexibility in its expressiveness and extensibility. A principal MPEG REL design goal is to enable and support significant extensibility from the basic data model. The MPEG REL is organized into several architectural parts:

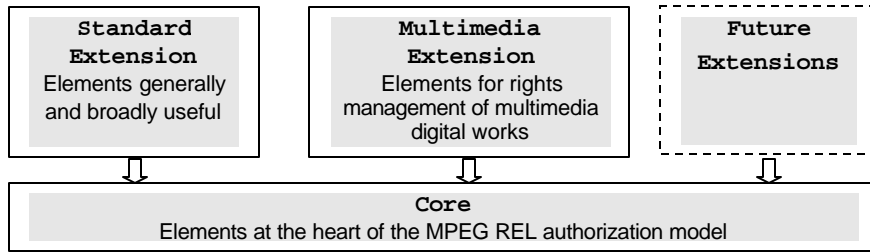


Figure 3: REL extension mechanism

The core, standard extension, and multimedia extension, as well as their XML Schemas, are normative parts of the overall MPEG REL specification. Other parties may, if they wish, define their own (possibly domain-specific) extensions to the MPEG REL and its future extensions, as shown in the diagram above. This is accomplished using the existing, standard XML Schema and XML Namespace mechanisms.

3 Profiles

Just as an application domain may need to develop its own MPEG REL extension to capture its own domain-specific elements (e.g. rights, resources and conditions), it may also wish to identify a conforming subset of the MPEG REL to meet its specific needs in order to facilitate compliance and interoperability among its applications and systems. This is where profiles come into the picture.

This section describes the general concept of a profile, and provides a list of principles for defining profiles for a standard or standards written using the W3C XML schema [3] like the MPEG REL.

3.1 Concept

According to an ISO document on profiles [5], a profile identifies a set of one or more base standards (or specifications in general), together with appropriate options and parameters necessary to accomplish identified functions for the purposes of optimization and interoperability.

More specifically, a profile specifies a particular use of a base standard, or a set of base standards, in order to meet specific needs in an optimized yet interoperable way for a community (e.g., electronic books or mobile devices), an application (e.g., media streaming), a function (e.g., certifying and attesting assertions), or an environment (e.g., North America, Europe or Asia). Thus, a profile provides a specification for product vendors to build interoperable special-purpose products, as well as providing the same specification for profile-compliant product users to reference for functionality and applicability of the products. Clearly, for each set of base standards, more than one profile may be developed to achieve different objectives.

In general, a syntactic, semantic or processing feature in the base standards can be mandatory, optional, or conditional (e.g., depending on the presence of other features). Mandatory features in the base standards shall be included in the profile and shall remain mandatory. If a feature is optional or conditional in the base standards, the feature can become mandatory, remain optional or conditional, or can be excluded in the profile. In changing the status of the feature, the profile

must not introduce any non-conformance to the base standards (especially when excluding a conditional feature).

If more than one profile exists for a same set of base standards, one profile may be considered as a finer profile than another if the former is also profile of the latter.

3.2 Specification

For standards written in the W3C XML Schema [3], a profile consists of syntactic, semantic, and processing rules for its intended use of the base standards. Since the XML Schema provides support for explicit structural, cardinality, datatyping, and extensibility constraints to XML elements and attributes, it enables specification of further constraints, refinements, and exclusions of existing namespace elements in the base standards.

The following are some guiding principles for determining these rules:

1. Syntactically, a profile must retain all required types, required elements, and their required attributes from the namespaces of the base standards. It must not introduce any new types, elements and attributes, which rules out any possible extension to the base standards. More specifically, wherever choices are left open in the base standards, it may select the following:
 - substructures (e.g., reduce the set of choice selections, omit optional elements),
 - limited cardinality (e.g., change an unbounded number of occurrences to one),
 - restricted data types (e.g., restrict the integer type to the positive integer type),
 - less extensibility (e.g., explicitly specify what elements can be in a substitution group), and
 - constrained values of elements and attributes (e.g., specific QNames and URIs).
2. Semantically, a profile must preserve all essential semantics for the types, elements and attributes it contains. It may choose to preserve and eliminate some elective semantic constraints, and for those preserved constraints, it may specify semantic constraints that are more specific than those of the base standards. However, it must not introduce any semantic constraints that would cause non-conformance to the base standards.
3. Processing-wise, a profile must keep all mandatory processing steps for all the types, elements, and attributes the profiles contains. It may choose to omit some optional processing steps, and impose additional processing steps that may refine, but must not contradict with, processing results as described in the base standards.

3.3 Conformance

With respect to conformance by any of its implementations, a profile should be considered an independent specification. Any implementation that creates REL expressions only using features in the profile should be considered as conformant to the base standards. On the other hand, any implementation that processes REL expressions with features in the base standards that are excluded from the profile may still be conformant to the profile, as long as the implementation conforms to the profile when it deals with the types, elements and attributes retained in the profile.

4 REL Requirements and Use Cases from Mobile Domain

This section illustrates the development process for an MPEG REL profile, using the mobile domain as an example. General requirements for a rights expression language (REL) are similar across multiple application domains. However, the mobile domain is unique in several aspects. One is that mobile devices have less computational power than general purpose computing devices. Another is that mobile devices may only need to support simple usage and distribution rights and conditions due to their limited user interactions and the controlled environment of a service provider network. Therefore, it is important to consider specific requirements from the mobile industry to develop use cases appropriate to this domain.

This section presents a general summary of some REL requirements for mobile or resource constrained devices and some sample use cases that reflect these requirements for the mobile domain.

4.1 Requirements

DRM systems for mobile devices should enable an issuer to grant the rights to play, print, and/or execute a digital resource. In addition, these rights over the digital resources shall be constrained with time restrictions and count limitations. Moreover, a particular user or a particular device can be specified as the principal that can exercise the usage rights over the digital resources.

Furthermore, the computational power required to interpret rights shall be efficient, so that mobile devices can easily process and enforce the rights. Security concerns such as the ability to digitally sign a rights license may be required as well as the ability to specify trust information.

4.2 Use Cases

The following use cases are derived from the above requirements, and they are representative of the current business models in the industry.

1. Playing a movie clip on a specific device: Wireless service providers want to allow consumers to play content on a specific device such as a cell phone.
2. Previewing a song on a specific device: An online music store allows consumers to play songs once on their cell phones.
3. Viewing an image during a limited time: A screensaver can be available for viewing on a cell phone for a limited time to entice the customer to purchase the image for viewing on a permanent basis. The time can be hours, days or years.
4. Viewing and printing a document on a PDA: A business traveler purchases a customized travel guide for her PDA. However, the rights issuer only allows the guide to be printed once and limits the viewing to one month from the purchase date.

5 REL Mobile Profile

Even though the MPEG REL in its entirety is capable of satisfying these requirements and supporting these use cases, creating a mobile profile of the MPEG REL can ensure that the computational requirements on mobile devices are easily satisfied. While a generic example profile can be found in Annex G of the MPEG REL specification [1], this section presents another profile specifically for the mobile domain, called an REL mobile profile and identified

(hypothetically) with a URI “urn:mobile:rel-profile”. This profile is used to illustrate the profiling approach and specification of the resulting profile.

5.1 General Approach

A general approach for creating a profile of the MPEG REL specification suitable for a mobile DRM system is to start with the whole set of MPEG REL types, elements and attributes in their entirety, namely all those defined in the core, standard extension and multimedia extension. First, the mandatory set of types, elements and attributes from the “whole set” must be selected and incorporated into the profile. This mandatory set must be included in every MPEG REL profile.

The next step involves selecting from the remaining optional types, elements and attributes. This includes selecting recursively from those subtypes, child elements and their attributes of the ones that have been selected for inclusion in the profile. These choices should be made after careful consideration of the requirements. The occurrences or cardinality of elements and their attributes can be restricted to match the requirements of a particular domain. In addition, the values of elements and attributes chosen in the new profile may also be restricted.

The last step entails the consolidation of the actual semantics of the MPEG REL. The semantics described in the profile specification may place additional mandates on how these types, elements, and attributes may be used. For example, one must specify a corresponding digital resource when specifying the “play” right. These types of semantic mandates, if any, must be clearly specified in the profile.

All the above steps help define and consolidate the syntax, semantics, and processing rules of the new profile. However, before the above steps are taken, a good understanding of the requirements for an REL for the mobile domain is crucial.

5.2 Analysis of Mobile Domain Requirements

Based on the requirements summarized in Section 4, there are two distinct sets of requirements to be drawn from; namely one set of requirements that can be used to derive an REL profile and the other set of requirements that are general and apply to any REL for a mobile DRM system. The first set contains the following requirements.

- R-1 The REL profile shall support an issuer to grant rights over digital resources. The profile must provide a mechanism to specify the issuer of these rights.
- R-2 The REL profile shall support the following set of usage rights over a digital resource:
 - play,
 - execute, and
 - print.
- R-3 The REL profile shall support a limited set of restrictions over the usage rights:
 - the number of times a resource may be accessed,
 - a time interval during which a resource may be accessed
- R-4 The REL profile shall support uniquely identifiable digital resources.
- R-5 The REL profile shall support a principal (a specific user or a specific device) to exercise the stated usage rights over an identified digital resource.

The second set of general REL requirements contains :

- R-6 The language of the profile shall be expressive.
- R-7 The language shall be non-ambiguous and explicit.
- R-8 Processing any REL expression for the mobile domain shall not be computationally expensive.
- R-9 The REL profile shall be simple enough so that it can be quickly implemented and deployed.
- R-10 The REL profile shall support the specification of rights independent of the type of content.
- R-11 REL expressions shall be independent of the transport mechanism.
- R-12 The REL profile shall provide a straightforward and a simple way of articulating rights pertaining to resources and principals.

5.3 Profile Elements

Based on the analysis of mobile domain requirements, the normative components of the REL mobile profile are presented in terms of the syntax and cardinality of the permitted elements in the profile. These elements and their included child elements are listed in the following table along with the cardinality restrictions on the ones originally in the MPEG REL. Any optional child elements and attributes that are not listed are excluded from the profile. The rationales for the selection and restriction (if any) of these elements are provided in the comments column.

Note that the namespace prefixes “r:”, “sx:” and “mx:” for the elements stand for the namespaces of the core, standard extension, and multimedia extension of the MPEG REL, and that the R-1 to R-5 in the comments column refer to the five REL requirements in Section 5.2.

Element / Child Element	Occurrence in Profile	Occurrence in REL	Comments
r:license			
r:grant	1..unbounded	0..unbounded	“r:license” is a mandatory element in the MPEG REL, so it must be included in the profile. However, “r:grant” is mandatory in the profile so every profile license is used for granting at least some rights.
r:issuer	1..1	0..unbounded	“r:issuer” is included as a required element in the profile to meet R-1. However, one and only one issuer is allowed in each license in this profile.
sx:profileCompliance	0..1	0..1	“sx:profileCompliance” is an attribute, included in this profile as the mechanism to allow any “r:license” to claim that it is compliant with this profile.
r:grant			
r:keyHolder	0..1	0..1	The principal element of “r:grant” is an abstract type and must be

			substituted. In this profile, “r:keyHolder” is used as the actual principal and it’s now the only allowed principal element. This satisfies R-5.
mx:play mx:print mx:execute	1..1	1..1	This profile only supports the “play”, “print”, and “execute” rights to comply with R-2.
mx:diReference	1..1	0..1	The “play”, “print”, and “execute” rights shall have an associated resource. Therefore, the profile requires this specific resource element to be present. It substitutes the abstract resource element of “r:grant”. This satisfies R-4.
r:validityInterval sx:validityIntervalFloating sx:exerciseLimit r:allConditions	0..1	0..1	Zero or one condition may appear directly in a grant. The “r:condition” is an abstract element that will be substituted by the actual ones listed here. If more than one condition is to be specified conjunctively, then use the “r:allConditions” element.
r:keyHolder			
r:info	1..1	1..1	The child element “info” is retained in the profile (but its child elements are further restricted as shown in the next section).
mx:direference			
mx:identifier	1..1	0..1	The rights supported in this profile must apply to a resource. Therefore, the identifier is now a required element in this profile.
r:allConditions			
r:condition	0..unbounded	0..unbounded	The r:allCondition element is retained in the profile, so that other conditions can be grouped together by it and used conjunctively.
r:validityInterval			
r:notBefore	0..1	0..1	“r:validityInterval” is a specific condition element that replaces the “r:condition” abstract type. This validity interval satisfies R-3.
r:notAfter	0..1	0..1	See above.
sx:validityIntervalFloating			
sx:duration	1..1	0..1	“sx:validityIntervalFloating” is a specific condition element that replaces the “r:condition” abstract type. This floating interval satisfies R-3.

sx:exerciseLimit			
sx:count	1..1	0..1	“sx:exerciseLimit” is a specific condition element that replaces the “r:condition” abstract type. The “sx:count” element is now required when specifying an “sx:exerciseLimit”. This satisfies the count restriction R-3.
r:issuer			
r:keyHolder	1..1	0..1	The actual issuer must be specified using one “r:keyHolder”.

5.4 Additional Conformance Restrictions

An MPEG REL document that desires compliance with the REL mobile profile must use the elements in the profile as defined in the previous section. In addition, an MPEG REL license that seeks conformance with the profile must also adhere to restrictions listed in the table below:

Element	Additional Restrictions
r:license	A license may have more than one grant. But all the grants in a particular license must apply to the same principal and the same resource.
r:keyHolder	Its child element “info” contains one and only one “dsig:KeyName” element.

The compliance with this profile can be achieved by using only the elements listed in the profile definition and following the specified restrictions.

6 Validating the REL Mobile Profile

One way to validate that a certain profile meets its requirements is to test it against the use cases from which the requirements are derived. In this section the four use cases from the mobile domain in section 4.2 are presented in detail along with the corresponding REL licenses expressed in the REL mobile profile. The adequate REL expressions for these use cases demonstrate the expressiveness and efficiency of the profile.

6.1 Allowing Play on a Specific Device

A content provider issues the license shown below to a user, granting the right to play a movie clip on the user’s cell phone. The **keyHolder** element identifies the principal of the grant, which in this case is the user’s cell phone. The **mx:diReference** element identifies the resource to which the grant applies, which is identified by the URI `urn:mpeg:movie:lord-of-rings.mpeg`. The **issuer** element identifies the license issuer, which in this case is the name of the issuer’s signing key.

```
<license xmlns="urn:mpeg:mpeg21:2003:01-REL-R-NS" xmlns:dsig="http://www.w3.org/2000/09/xmldsig#"
xmlns:mx="urn:mpeg:mpeg21:2003:01-REL-MX-NS" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation="urn:mpeg:mpeg21:2003:01-REL-R-NS rel-r-profile.xsd" profileCompliance="urn:mpeg:rel-profile">
  <grant>
    <keyHolder>
      <info>
```


6.3 Viewing a Screensaver for a Limited Time Period

A user is allowed to have a screensaver for a period of one month. In the license below, the user's cell phone, identified by a **keyholder** is only allowed to exercise the **mx:play** right on the screensaver identified with **mx:diReference** only if the time of exercising the right lies within the interval specified by **notBefore** and **notAfter** of the **validityInterval** condition.

```
<license xmlns="urn:mpeg:mpeg21:2003:01-REL-R-NS" xmlns:dsig="http://www.w3.org/2000/09/xmldsig#"
xmlns:mx="urn:mpeg:mpeg21:2003:01-REL-MX-NS" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation="urn:mpeg:mpeg21:2003:01-REL-R-NS rel-r-profile.xsd" profileCompliance="urn:mpeg:mpeg21:2003:01-REL-R-NS rel-r-profile">
  <grant>
    <keyHolder>
      <info>
        <dsig:KeyName>User's cellphone key</dsig:KeyName>
      </info>
    </keyHolder>
    <mx:play/>
    <mx:diReference>
      <mx:identifier>urn:mpeg:mpeg21:2003:01-REL-MX-NS:photos:expenseive.jpg</mx:identifier>
    </mx:diReference>
    <validityInterval>
      <notBefore>2003-02-13T15:30:00</notBefore>
      <notAfter>2003-03-13T15:30:00</notAfter>
    </validityInterval>
  </grant>
  <issuer>
    <keyHolder>
      <info>
        <dsig:KeyName>Content provider' signing key</dsig:KeyName>
      </info>
    </keyHolder>
  </issuer>
</license>
```

6.4 Viewing and Printing a Document on a PDA

A business traveler is stranded in New York and purchases a customized travel guide for her PDA. The content provider allows her unlimited views of the travel guide during a period of one month (which starts immediately after the purchase date). However, the business traveler can print the document only once during the same time period. In the license below there are two grants: one that gives the user's PDA the unlimited play right within the specified time interval and the other that limits the number of times the user's PDA can exercise the **mx:print** right to one within the same time interval.

```
<license xmlns="urn:mpeg:mpeg21:2003:01-REL-R-NS" xmlns:dsig="http://www.w3.org/2000/09/xmldsig#"
xmlns:mx="urn:mpeg:mpeg21:2003:01-REL-MX-NS" xmlns:sx="urn:mpeg:mpeg21:2003:01-REL-SX-NS"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:schemaLocation="urn:mpeg:mpeg21:2003:01-REL-R-NS rel-r-profile.xsd" profileCompliance="urn:mpeg:mpeg21:2003:01-REL-R-NS rel-r-profile">
  <grant>
    <keyHolder>
      <info>
        <dsig:KeyName>PDA Model 300 sc300NRG307NqJgmZ</dsig:KeyName>
      </info>
    </keyHolder>
    <mx:play/>
  </grant>
  <grant>
    <keyHolder>
      <info>
        <dsig:KeyName>PDA Model 300 sc300NRG307NqJgmZ</dsig:KeyName>
      </info>
    </keyHolder>
    <mx:print/>
  </grant>
  <issuer>
    <keyHolder>
      <info>
        <dsig:KeyName>Content provider' signing key</dsig:KeyName>
      </info>
    </keyHolder>
  </issuer>
</license>
```

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```

<mx:diReference>
  <mx:identifier>urn:mobile:travel:guides:ny:centralpark:34122948578946</mx:identifier>
</mx:diReference>
<validityInterval>
  <notBefore>2003-02-13T15:30:00</notBefore>
  <notAfter>2003-03-13T15:30:00</notAfter>
</validityInterval>
</grant>
<grant>
  <keyHolder>
    <info>
      <dsig:KeyName>PDA Model 300 sc300NRG307NqJgmZ</dsig:KeyName>
    </info>
  </keyHolder>
  <mx:print/>
  <mx:diReference>
    <mx:identifier>urn:mobile:travel:guides:ny:centralpark:34122948578946</mx:identifier>
  </mx:diReference>
  <allConditions>
    <validityInterval>
      <notBefore>2003-02-13T15:30:00</notBefore>
      <notAfter>2003-03-13T15:30:00</notAfter>
    </validityInterval>
    <sx:exerciseLimit>
      <sx:count>1</sx:count>
    </sx:exerciseLimit>
  </allConditions>
</grant>
<issuer>
  <keyHolder>
    <info>
      <dsig:KeyName>Content provider' signing key</dsig:KeyName>
    </info>
  </keyHolder>
</issuer>
</license>

```

7 Conclusion

Success of domain-specific DRM applications will benefit from appropriately developed profiles, as well as extensions, of the MPEG REL to meet specific needs. Developing profiles requires compliance with certain guidelines. A recipe (including concept, methodology and detailed examples) is presented in this paper as a reference for creating these profiles. Not only does it illustrate a requirement-driven process and an effective mechanism for generating and presenting a resulting MPEG REL profile, but it also proves the scalability of the MPEG REL, as intended in design, to support DRM applications, systems and devices of different scales. The resulting profile, although hypothetical, has demonstrated that licenses written in the MPEG REL can be both compact and expressive to support many use cases in mobile DRM applications. The lightweight licenses can reduce the computational resources required by mobile devices to process these licenses and hence are suited for, while maintain the applicability beyond, the mobile applications.

References

1. MPEG REL, ISO/IEC FDIS 21000-5: Information Technology — Multimedia Framework — Part 5: Rights Expression Language, August 2003.
2. Extensible Markup Language (XML) 1.0 (Second Edition), W3C Recommendation, 6 October 2002, available at <http://www.w3.org/TR/2000/REC-xml-20001006>
3. XML Schema Part 1: Structures and Part 2: Datatypes, W3C Recommendation, 2 May 2001, <http://www.w3.org/TR/2001/REC-xmlschema-1-20010502> and <http://www.w3.org/TR/2001/REC-xmlschema-2-20010502>.
4. Namespaces in XML, W3C Recommendation, 14 January 1999, <http://www.w3.org/TR/1999/REC-xml-names-19990114>.
5. ISO TR 10000: Framework and Taxonomy of International Standardized Profiles.