Exploiting MPEG-21 File Format for cross media content

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Abstract

Cross media and hypermedia content formats and related tools have to take into account aspects related to the protection and management of intellectual property right along the value chain from content production to content distribution up to the final user. In this view, the relevance of MPEG-21 standard is growing also for the B2B manipulation of digital objects, using the nested levels of protection in the B2B exchanges. When studying how to map the produced nested Digital Items on the File Format standard several difficulties have been faced since the MPEG-21 have limitations in managing protected nested levels that are very relevant for the B2B activities. The paper discusses them and proposes solutions that have been realized in the AXMEDIS models and tools. AXMEDIS is a research and development integrated project of the European Commission.

Keywords*: MPEG-21, content distribution, File format, nested protecting levels, B2B packaging. .*

1 Introduction

The solutions for digital content distribution and e-commerce are mainly based on the state of the art of multimedia content modeling, packaging, protection and distribution. At present, there exists a large number of content formats ranging from basic digital resources (documents, videos, images, audio, multimedia, etc.) to integrated content packages such as: MPEG-21 ISO [4], WEDELMUSIC [2], SCORM [11], OMA (Open Mobile Alliance), TV-AnyTime Forum [7], etc. These integrated content formats try to wrap different kinds of digital resources/files in a container/package with their related information (e.g., content metadata and descriptors, relationships among resources, etc.) and they make such resources ready for delivery (streaming and/or downloading), in plain (clear-text) and/or protected forms. In fact, some of the above mentioned solutions are enabling a large range of business and transaction models and provide some integrated DRM (Digital Rights Management) solutions to cope with Intellectually Property Right (IPR), such as those based on MPEG-21 REL (MPEG Rights Expression Language) [15], OMA ODRL (Open Digital Rights Language) [8], and others [10], [9].

In AXMEDIS (Automating Production of Cross Media Content for Multi-channel Distribution) [1], the MPEG-21 DI (Digital Item) has been adopted as a basis to realize a platform to produce, protect and distribute cross-media content in XML and binary formats. The AXMEDIS Data Model has conceived the so called AXMEDIS Object (the unit of distribution) as an MPEG-21 DI, with specific structuring, metadata, descriptors and capabilities for nesting levels of object composition and protection. AXMEDIS supports both DI representation XML files according to DIDL (Digital Item Description Language) and ISO (International Standard Organization) media File Format [6], [5], [14]. The work presented in this paper has been developed in AXMEDIS which is a large research and development Integrated Project FP6 of the European Commission DG INFSO (http://www.axmedis.org), [3].

This paper discusses an experience in using MPEG-21 Part 9 [14] to represents complex digital items, much more complex objects with respect to those presented as example in the standard. DIs. The issues are related to the above mentioned needs where MPEG-21 IPMP (Intellectual Property Management and Protection) is used for protecting sub-parts (DIDL Item elements). The target of the protection can be an Item element which includes protected Item elements. In this paper, a solution for representing such DIs in terms of File Format (FF) has been outlined. This paper aims at explaining about how the MPEG-21 Standard (Part 9) can be used (extended in terms of semantics) to model complex objects by using the solutions proposed in AXMEDIS. The solutions proposed impacts on the realization of DIs representing multimedia presentations, based on HTML and/or SMIL (as presentation models) and on digital resources and links and nested DIs [3].

2 MPEG-21 File format and protection issues

The standardization of the file format of MPEG-21 has basically reused the ISO media standard produced for MPEG-4 [14]. This choice produced a very simple specification for which the MPEG-21 description

(DIDL [12], IPMP [13], etc.) has to be included in the XMLBox inside a MetaBox as in the example of Figure 1.

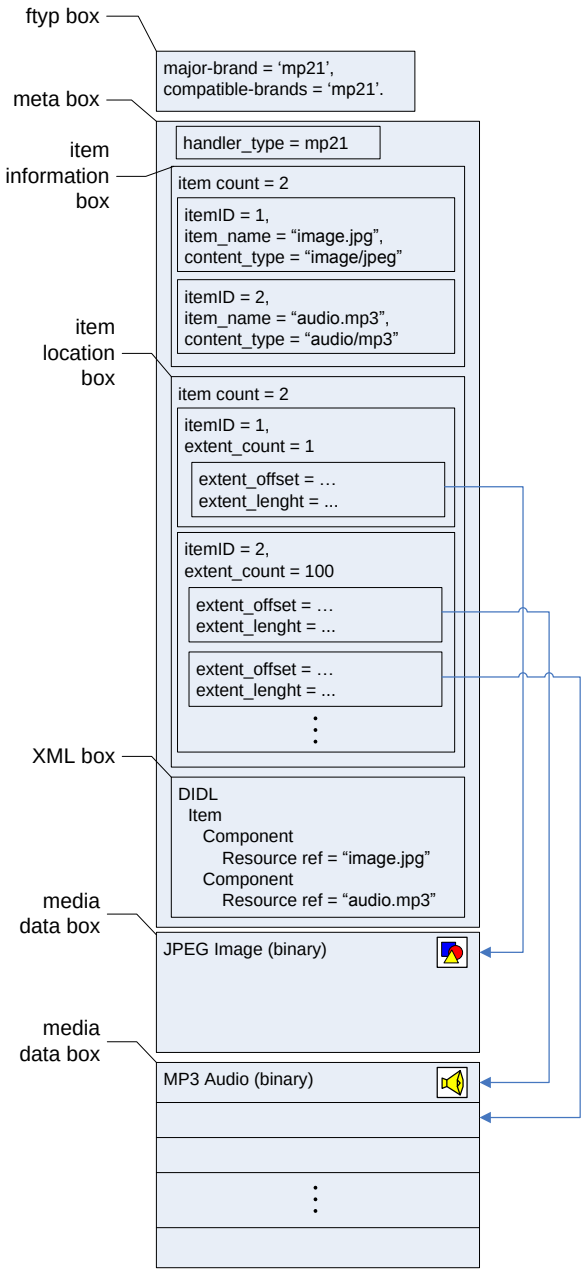

Figure 1 – File format example

In that manner, a placeholder for MPEG-21 based description has been reserved; media components can be located in proper MediaDataBox and referred by the XML structure using references. A DI that includes an image and an audio file can be represented in MPEG-21 FF as depicted in Figure 1. Please note that DIDL structure refers to "*image.jpg*" and "*audio.mp3*": the proposed semantics requires a player to resolve those references by accessing to the proper MediaDataBox. For that reason the ItemInformationBox is populated with the media in order to be accessed by the player (i.e., loaded at the opening). The ItemInformationBox is linked with the ItemLocationBox on the basis of the "itemID", the second one represents a look-up table for selecting the file portion that includes a given resource.

The XML Box sketched in Figure 1 is reported in the following box with more details.

```
<?xml version="1.0" encoding="UTF-8"?>
<DIDL xmlns:xi="http://www.w3.org/2001/XInclude"
xmlns:dii="urn:mpeg:mpeg21:2002:01-DII-NS"
xmlns="urn:mpeg:mpeg21:2002:02-DIDL-NS"
xmlns:ipmpdidl="urn:mpeg:mpeg21:2004:01-IPMPDIDL-NS"
xmlns:ipmpinfo="urn:mpeg:mpeg21:2004:01-IPMPINFO-NS"
xmlns:dc="http://www.w3.org/1999/02/22-rdf-syntax-ns#">
<Item>
    <Descriptor>
        <Statement mimeType="text/xml">
        <dii:Identifier>urn:axmedis:00000:obj:…axoid…</dii:Identifier>
        </Statement>
    </Descriptor>
    <Descriptor>
        <Statement mimeType="text/xml">
        <AXInfo xmlns="urn:axmedis:01">
            … missing B2B related metadata…
        <AXInfo>
        </Statement>
    </Descriptor>
    <Descriptor>
        <Statement mimeType="text/xml">
        <dc:Description >
            … missing DublinCore metadata…
        </Description>
        </Statement>
    </Descriptor>
    <Component id="poster">
        <Resource mimeType="image/jpeg" ref="image.jpg"/>
    </Component>
    <Component id="music">
        <Resource mimeType="audio/mp3" ref="audio.mp3"/>
    </Component>
</Item>
</DIDL>
```

The advantage of producing a MPEG-21 file in the File Format (FF) version, and not as a XML file, allows supporting interoperability and the possibility of including media resources in their original binary format. The solution only based on XML (see above) may refer at outside resources, losing in this manner, the possibility of delivering the collection of files as a unique "package". An alternative can be to embed resources into XML by encoding them in base64, enlarging in that manner the size of 30%. The advantage of the FF based solution consists in the fact that resources are directly accessed, even without the need of processing XML, since the information which is needed to access and to render a resource is the mime-type (to select the proper parser/renderer) and the location to begin reading them and their end in

terms of offsets inside the file. This data is in the FF MetaBox.

When everything is in clear-text/XML simple actions are required to produce a FF DI: to ideally detach the resource from the structure and substitute with proper references, then to write the XML and the media in separate portions of information.

2.1 Representing protected DIs

When DI part is protected, problems arises on how to represent content in the FF. MPEG-21 standard defined IPMP Components as the protection elements of a DIDL-based structure in order to protect a DI element the proper IPMP element has to replace the corresponding DIDL [13].

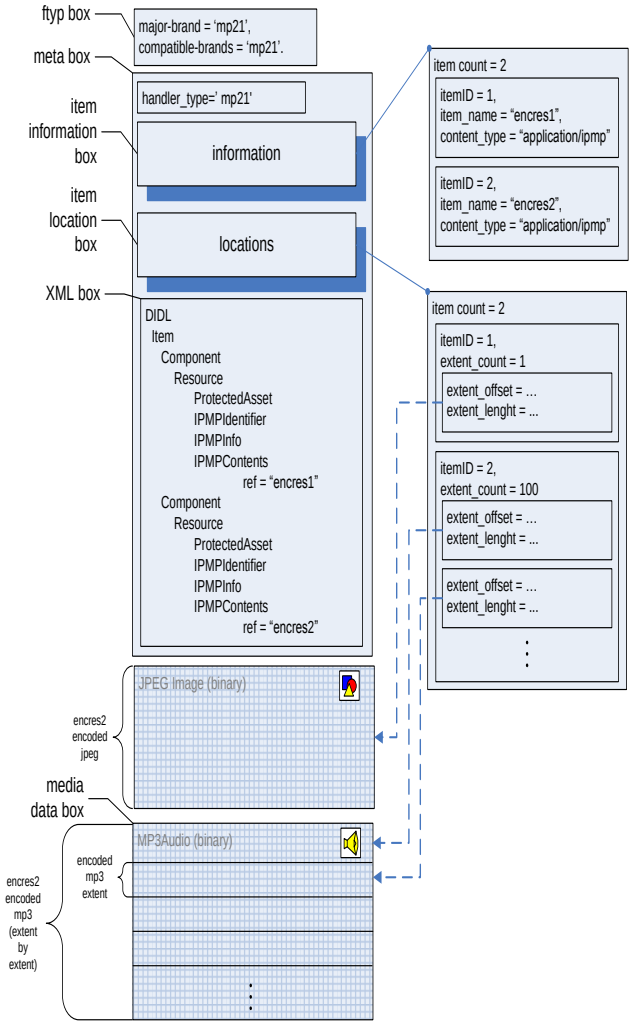

Figure 2 – Simple protection (only digital resources)

In Figure 2, the result of protecting the resources that have been embedded in the MPEG-21 file is shown. In this case, all the information is contained in the XMLBox and the player accesses at the resource just after it acquires how to process (e.g., unprotect) it with the proper IPMPTool (described in the IPMP Info). A variation is also shown about how to encode the digital resource: using the extents of the clear-text resource, the encoded one can be divided into extents in order to allow on-line unprotection and rendering mechanisms. In Figure 2, resources have been represented in the XML Box with the proper tag ProtectedAsset which can be embedded inside a Resource in order to notice that the content inside have to be processed by a suitable IPMP Tool before obtaining the clear-text digital resource according to the mime-type.

Problems arise when the protection is applied on other elements together with the digital resources. In AXMEDIS, the DIDL Item is the basic distribution element and in this case the complete Item content has to be protected by replacing it with an IPMP Item. A solution can be to protect the whole XML element with the embedded digital resources that have to be included "by value" and encoded with base64.

A solution can be realized by performing a two-step protection process (see Figure 3): first encoding the digital resources as in the first case (see Figure 2), then protecting the Item element, that is now linked to the digital resource with references, in the corresponding IPMP Item. In this last solution, the accessibility of digital resource is preserved, and a box-like protection is performed, thus protecting metadata and other elements with related advantages for protecting the enriched metadata. Please note that the IPMPInfo element has to be defined for the Item elements and for the ProtectedAsset elements.

The solution proposed in Figure 3 appears to be a good compromise between box protection and accessibility of the resources. In any case, this solution is still incomplete since does not consider the case of nested Digital Items, where an Item element contains other Item elements, and different protections are applied to each level. That case is the most promising use case for B2B transactions in which integrators and distributors are interested in repackaging content in nested level imposing their protection model and protecting at the same time their added value (e.g., presentation information, metadata, gluing information, etc.). On this regard, Figure 3 shows that protected content is directly included in the XML structure, this is possible by implicitly encoding the result of the IPMPTool processing in base64 (that ensures output is

a set of text characters that can be included in a XML text node) as depicted by the following XML Box extract.

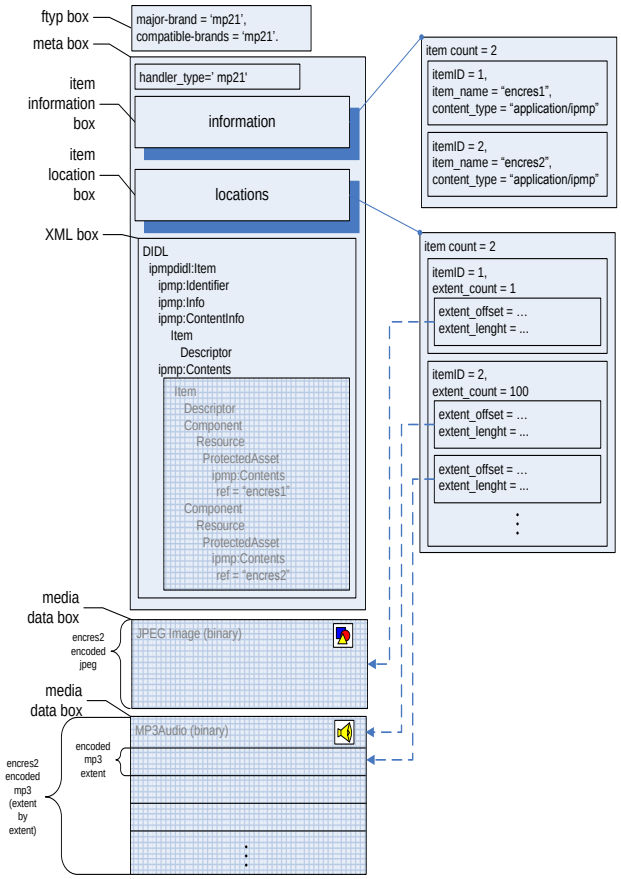

Figure 3 – Item element protection (two-steps protection, resources plus IPMPcontents)

Please note that the IPMP section into the XML box contain the protection information regarding the protected segment into the XML box itself.

```
<?xml version="1.0" encoding="UTF-8"?>
<DIDL xmlns:xi="http://www.w3.org/2001/XInclude"
xmlns:dii="urn:mpeg:mpeg21:2002:01-DII-NS"
xmlns="urn:mpeg:mpeg21:2002:02-DIDL-NS"
xmlns:ipmpdidl="urn:mpeg:mpeg21:2004:01-IPMPDIDL-NS"
xmlns:ipmpinfo="urn:mpeg:mpeg21:2004:01-IPMPINFO-NS"
xmlns:dc="http://www.w3.org/1999/02/22-rdf-syntax-ns#">
<ipmpdidl:Item>
      <ipmpdidl:Identifier>
      <dii:Identifier>urn:axmedis:00000:obj:…axoid…</dii:Identifier>
      <ipmpdidl:Info>
            … omitted IPMPTool information …
      </ipmpdidl:Info>
      <ipmpdidl:ContentInfo>
            … omitted Content metadata …
      </ipmpdidl:ContentInfo>
      <ipmpdidl:Contents>
/9j/4AAQSkZJRgABAQEAyADIAAD/2wBDAAUDBAQEAwUEBAQFBQ
UGBwwIBwcHBw8LCwkMEQ8SEhEPERETFhwXExQaFRERGCEYGh
0dHx8fExciJCIeJBweHx7/2wBDAQUFBQcGBw4ICA4eFBEUHh4eHh4e
Hh4eHh4eHh4eHh4eHh4eHh4eHh4eHh4eHh4eHh4eHh4eH
h4eHh7/wAARCAEKAMgDASIAAhEBAxEB/8QAHAAAAQUBAQEAAA
AAAAAAAAAAAwECBAUHAAYI/…… ….
… result of the protection of clear-text <Item><Descriptor> etc…
      </ipmpdidl:Contents>
</ipmpdidl:Item>
</DIDL>
```

As proposed in the solution depicted in Figure 3, when the protection is applied, the link between the container and the digital resource is lost, because the reference is hidden by the protection. In this case, it is impossible to determine which resource belongs to the Item element represented in the XMLBox. This situation based on nested DIs provokes the lost of the association between encoded digital resources and the corresponding Item elements. If the extraction of a sub-part of the DI (i.e., Item element) is required during the DI processing by any tool (e.g., Authoring tool, automatic production, etc.), a complete unprotection of all nested levels in order to select which digital resource has to be moved together with the XML portion.

The same problem arises when a tool requires protecting an Item element which includes IPMP Item elements. As stated above, in our B2B model and use case, to protect the result of an integration of different DIs means to encode the whole DI (i.e., the Root Item Element) with an IPMP Tool. This requirement imposes to process also the attached digital resources with the same encoding. Therefore, the two-steps protection is performed at any level: in this way, if a tool needs to render a given digital resource has to unprotect all the higher nested levels. In the following section, a solution for managing compounded DIs, structured with nested levels that could be protected is presented, highlighting the lack of flexibility of the MPEG-21 FF without the proposed solution.

This case shown is of great importance for B2B activities (as in the AXMEDIS platform and tools) since a business requirements state that: "*distributable media has to be protected and can be used for integration. When integrated a new protection has to be applied to the obtained content in order to protect the value of the integration itself*".

3 Proposed mapping of nested protected DIs

The AXMEDIS solution allows associating structure elements with encoded digital resource on the basis of AXMEDIS Object Identifiers (AXOIDs). Any encoded digital resource is named using the container's AXOID as its prefix (i.e., axoid0000_res0). AXMEDIS requires also that the produced DIs, if protected, has to expose in a proper placeholder a description of

everything is contained inside (and for protection is not directly visible). The ContentInfo element of IPMP components has been designed to include information about protected content: in AXMEDIS the identifiers of the inner levels of the nested structure and related metadata are reported in this element.

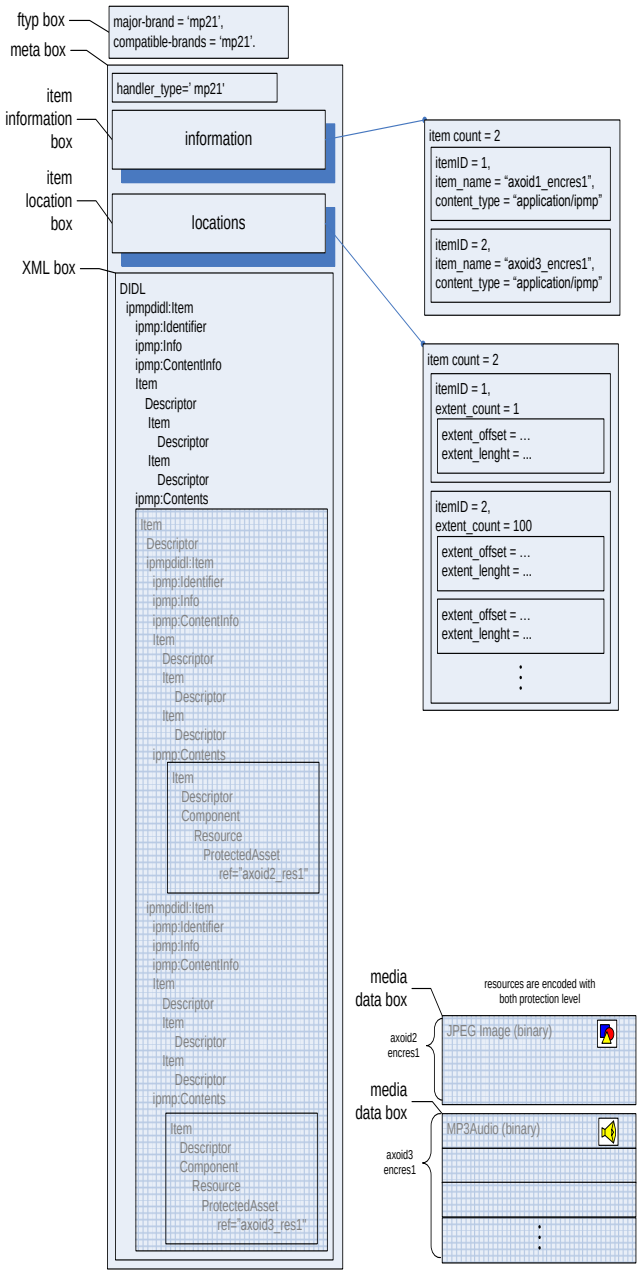

Figure 4 – Two nested levels DI with a protection at each level

The two solutions (i.e., AXOID-based reference, and AXOIDs of protected content) allow to always associate DI structure with encoded digital resources as depicted in Figure 4. The Figure 4 shows how to represent a DI, which contains an outer Item element that, in turn, contains two other Item elements, and the latter contains a digital resource each. The presented DI has been created by starting from the composition/reuse of two MPEG-21 DIs modeled as depicted in Figure 3. In their separate models, each of them was endowed of protected digital resources and protected IPMPDIDL contents into their corresponding XML Box.

When these two MPEG-21 objects are compounded together to create a new composite object (e.g., a collection, an album, etc.), their MediaDataBox are protected with an additional nesting level (enforcing the protection of the integrator, increasing security and the controllability). In addition, the IPMPDIDL contents containing the XML box of the components is protected as well as a unique blob hiding the details of the decomposition and thus avoiding the direct access to the components without activating the unprotection imposed by the integrator.

The proposed solution balances between box-like protection and digital resource accessibility. The most evident drawback is that is implicitly assumed that a given digital resource has been protected with all the IPMP Tools that have been used for the container boxes. For example, *axoid1_encres1* in Figure 4 has been protected with the IPMP Tools that are specified by the protection of the first (the root IPMP Item element) and the second nesting level (IPMP Item that contains *axoid1_encres1*).

The above solution has been adopted for the limitations of the MPEG-21 format. In fact, there is no way of specifying directly in the FF which protection has been used in terms of MPEG-21, but only in terms of MPEG-4 IPMPX, supposing probably of hosting into the MPEG-21 packages only MPEG-4 resources. The drawback of this approach in formalizing the FF is to lose flexibility with respect to what can be done by using XML. The MPEG-21 standard FF excludes some of the technologies that have been included by MPEG-21 by confining it in the XML box, limiting the usage of the MPEG-21 as a general packager. The IPMP components would require a more intensive integration with the FF specification in order to really map on that binary format what can be obtained by using XML. Thus these problems have been solved by using the above mentioned solution in AXMEDIS MPEG-21 solutions and tools. The proposed solution allows obtaining nested levels of protection preserving fast access to digital resources.

4 Conclusions

AXMEDIS is proposing a solution and platform, based on MPEG-21 standard that address also B2B content distribution and exploitation requirements. When studying how to map the produced DIs on the File Format standard several problems have been faced. The proposed solution is capable, with the present structure of the MPEG-21 standard FF (File Format), of solving the above mentioned problems, permitting direct access to the information. The AXMEDIS platform includes editor, authoring tools and players for PC, PDA, and mobiles. All tools are accessible for free from www.AXMEDIS.org .

The hardest challenge is when DI is structured as a nested container and at each level protection can be applied by using IPMP components. In this case, two solutions have been designed: i) encoding inner level by value in the XML ii) separating digital resources in the proper MediaDataBox while applying on them all the protections required on the basis of the level in the DI they belong to. The first is not efficient in terms of digital resource access and makes useless the File Format with respect to a simple XML document. The second is based on the implicit assumption that digital resources are encoded with all the IPMP tools of the upper nested levels. The proposed solution allows obtaining nested levels of protection preserving fast access to digital resources.

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