Interoperable Preservation Metadata for Multimedia Content

Werner Bailer, Georg Thallinger

JOANNEUM RESEARCH
DIGITAL – Institute for Information and Communication Technologies
Graz, Austria

{werner.bailer, georg.thallinger}@joanneum.at

Abstract

Interoperable metadata is a key prerequisite for long-term preservation and quality assurance of multimedia content. For preservation purposes, the following two types of metadata are most crucial: structural metadata, i.e., metadata that is needed to correctly interpret the stored essence, and preservation metadata, which includes information about the fixity, integrity and authenticity of the object, its condition and quality, as well as documentation of the provenance and preservation actions applied. While an abundance of metadata standards and formats for describing multimedia content exists, this is not the case for the description of material properties, tools and processes for preservation of audiovisual content.
Within the ISO/IEC MPEG group, an initiative called Multimedia Preservation Application Format (MP-AF) is defining a data model for representing preservation metadata for multimedia content, addressing a broad range of institutions, from dedicated audiovisual archives to national libraries or museums, which may have some multimedia content in their collection. The model includes the following metadata categories: provenance, context, reference, quality, integrity, authentication, fixity and rights. The specification of MP-AF contains a high-level data model, the specific metadata structures for the different types of preservation metadata, and a core set of these metadata that is required to ensure minimum interoperability.

1 Introduction

Interoperable metadata is a key prerequisite for long-term preservation and quality assurance of multimedia content. For preservation purposes, the fol-

lowing two types of metadata are most crucial: *structural* metadata, i.e., metadata that is needed to correctly interpret the stored essence (header structures of containers, technical metadata about the type of encoding, etc.), and *preservation* metadata, which includes information about the fixity, integrity and authenticity of the object (i.e., properties that allow checking the integrity and quality of the essence), its condition and quality, as well as a documentation of the provenance, including related rights, and preservation actions applied (e.g., devices/tools used and their parameters).

While an abundance of metadata standards and formats for describing multimedia content exists, this is not the case for the description of material properties, tools and processes for preservation of audiovisual content. Preservation metadata is a relatively new concept, and preservation metadata models emerged quite recently in the digital library domain. The most important of these models is PREMIS (cf. PREMIS 2012), a model proposed by the US Library of Congress. It defines a high-level data model and a set of properties for each of the entities in the model. An XML representation exists and an OWL (Web Ontology Language) representation has recently been proposed.[1] In connection with multimedia, the implementation of PREMIS elements in MPEG-21 Digital Item Declaration (DID) containers (cf. Bekaert/De Kooning/Van de Sompel 2006) has been proposed. An early attempt from the multimedia area is the MPEG Professional Archive Application Format (PA-AF) (cf. MPEG 2009). However, its focus is on specifying a virtual folder format for packaging multiple items into a single file conforming to the ISO file format, while providing only very basic metadata support.

Various approaches to document the knowledge involved in preservation processes have been proposed, such as obsolescence of media formats, using registries and associated file identification tools (e.g., PRONOM, JHOVE, FIDO). However, these databases make the assumption of a monolithic file, while in the audiovisual domain we usually deal with containers wrapping a number of different streams (video, audio, possibly others such as time codes and subtitles). Obsolescence and risks do not only apply to the container, but also to each of the contained streams, which has its own encoding. This impacts whether tools for decoding the stream are available as well as the vulnerability of the data in the stream. In addition, modern containers such as MXF offer a variety of options for multiplexing streams in the container.

The existing preservation metadata formats originating from the digital library domain only superficially cover the significant properties and the proc-

1 http://id.loc.gov/ontologies/premis.html

esses involved in preserving multimedia data. In contrast, standards from the audiovisual domain only partly cover these properties, as they were designed with production in mind rather than preservation.

Interoperable preservation metadata is not so much an issue for the data model of a specific repository or preservation system, but rather in cases where content and related metadata need to be exchanged between preservation systems. This includes for example transfer of content between repositories, changes or upgrades of preservation systems, exchange with service providers taking over certain tasks in the preservation workflow and organisations providing preservation services for other organisations. The latter is often the case for larger (e.g. national) archives taking over long-term preservation for smaller institutions for which maintaining their own infrastructure is not cost-efficient.

The Open Archival Information System (OAIS) (cf. CCSDS 2012) model is a common reference model for preservation systems (see Figure 1). In the context of OAIS, interoperable preservation metadata is needed for ingesting content into the system (Submission Information Package, SIP) or accessing content from the system (Distribution Information Package, DIP). The metadata required for multimedia preservation, which is not adequately covered by existing technologies, mostly falls into a specific OAIS object metadata category called Preservation Description Information (PDI).

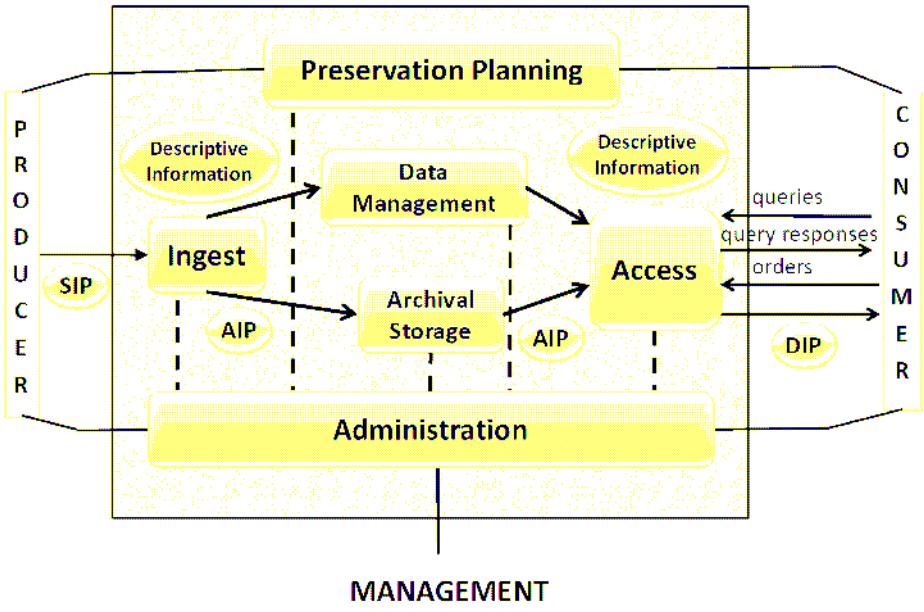

Figure 1 The OAIS reference model (CCSDS 2012: 4-1)

This paper presents the status of the work on a new multimedia preservation metadata standard in the ISO/IEC MPEG group. Section 2 discusses the context and the requirements of this work. In section 3, we present the draft version (cf. Bailer et al. 2013) of the data model, and its relation to other formats and standards is described in section 4. Section 5 discusses open issues and outlines the standardisation roadmap.

2 Towards a Standard for Multimedia Preservation Metadata

Within the ISO/IEC MPEG group, work on defining an interoperable set of preservation metadata for multimedia content has started. The initiative is called Multimedia Preservation Application Format (MP-AF) and aims at defining a data model for representing preservation metadata for multimedia content. The group addresses a broad range of institutions, from dedicated audiovisual archives to national libraries or museums, which may have among others some multimedia content in their collection.

In 2011–2012, requirements have been gathered by consultations with different stakeholders involved, resulting in a requirements document (cf. MPEG Requirements 2012). The following types of metadata have been identified as relevant for inclusion in MP-AF:

- *Provenance* describes the creation of the resources, such as who produced it and who has had custody since its origination, and its history (including processing history).
- *Context* describes the circumstances that resulted in the production of the resource and how the preserved information relates to other information. For example, it would describe why the resource was produced, and it may include a description of how it relates to other resources available.
- *Reference* provides one or more identifiers, or systems of identifiers, by which the resources may be uniquely and persistently identified. Reference information supports the linkage of identical or related resources that may be stored in separate repositories under different local identifiers.
- *Quality* encompasses the information relating to the assessment of the properties of the resources and also how well it has been preserved. Quality information should include results of quality assessment after any transformation and information on the transformation processing procedures.

- *Integrity* encompasses the information relating to the presence, persistence, extent, or degree of the properties of the resource over time. Integrity information should also include the history of any environmental and/or systems changes.
- *Authentication* encompasses the information relating to authenticity – origin of or creation of – for a given resource. Authentication information should also include the history of any legal transfer of ownership from one source to another.
- *Fixity* encompasses the information ensuring that properties of the resource have not been altered in an undocumented manner. As described by OAIS, fixity is one method documenting the integrity of the resource.
- *Rights* encompasses the information concerning legal, regulatory, or contractual provisions that affect ownership, control, or use of resources, e.g., intellectual property, copyrights, privacy, etc. insofar as they impact preservation. Actions or events in the preservation of resources need to respect such rights.

For each of these metadata types, more detailed requirements in terms of the specific properties to be supported and the relation to content entities have been defined.

3 MP-AF Data Model

The specification of MP-AF contains three main components. The first is a high-level data model, specifying the top-level entities and their relations. The second part concerns the specific metadata structures for the different types of preservation metadata covered by MP-AF. These definitions make use of existing metadata standards whenever possible, e.g., using parts of MPEG-7, MPEG-21, or define extensions to existing metadata standards. The third part (not described in detail in this paper) defines a core set of these metadata that is required to ensure minimum interoperability between systems.

3.1 Core Data Model

The central entities in the model are those representing multimedia content. These content related entities are modelled to be compatible with the MPEG-21 Digital Item Declaration (DID), i.e., as *Containers* and *Digital Items*, which hold metadata and references to the actual essence. In order to align the model with data models in use in the media industry (and covering most

of the FRBR group 1 entities; cf. IFLA 1998) four levels of specializations are defined.

- A *Preservation Object* is a creation that retains intellectual or artistic attributes independently of its Representations. An *Asset* is a Preservation Object with a description of the owner and the owner's rights. These rights are exploitation rights different than the usage rights of a Digital Item. This is aligned with the definition of an asset by the Society of Motion Picture and Television Engineers (SMPTE), which defines asset as content plus rights. Preservation Objects may be recursively nested in order to express different groupings, which can also be treated as a single object (e.g., tracks of an audio CD and the entire CD). In contrast, *Group* is explicitly a container (i.e., collection) of Preservation Objects, and not an object itself.
- A *Representation* is the set of essence plus metadata needed for a complete and reasonable rendition of a Preservation Object. These levels of content entities are connected between each other by composition relations.
- An *Essence* is one or more non-encoded bitstreams that are necessary to render a certain media resource. All essence – and possibly metadata – is needed for complete rendition.
- While the essence is content itself, i.e., the (decoded) audiovisual data, the *Bitstream* is the stored (often compressed) representation. Essence and Bitstream are both Digital Items and *Components*, as both might be used as the lowest level in the description of the content hierarchy. Components contain *Media Locators*, pointing to digital resources or their analogue sources, if applicable.

Apart from the content hierarchy, the MP-AF data model provides entities for representing preservation activities. *Activity* represents a preservation action applied by *Operators* to Preservation Objects, Components or Groups. Activities may be nested and therefore, they are able to model processes, subprocesses and simple tasks as well.

Operators are persons, organisations or systems that can be instantiated as *Agents* (persons, organisations) or *Tools* (hardware devices, software applications). They are involved in a certain Activity with a specific role. Agents can have relations between them.

The complete data model is shown in Figure 2. Relations are included in the model diagram as one of the following types: inheritance (the entity is a specialization of another entity and inheriting the parent's attributes), composition/aggregation (the entity contains other entities) or associations (with the meaning of the association included as text).

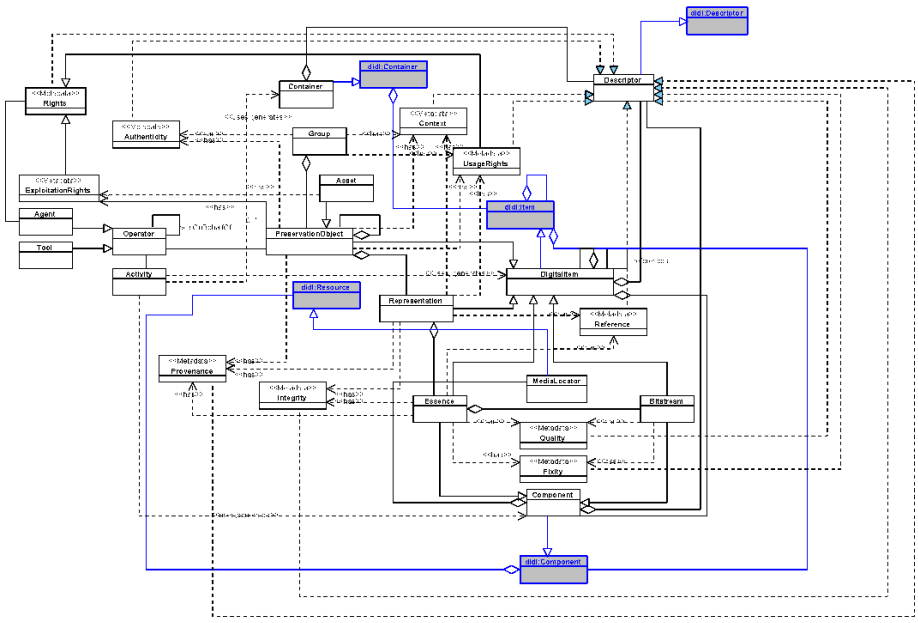

Figure 2 Core MP-AF data model; entities from MPEG-21 DID are highlighted

The data model contains entities with a <<*Metadata*>> stereotype, which correspond to the metadata types specified in the MP-AF requirements. These entities might correspond to a single or a set of the descriptors in a concrete representation of the model. Table 1 provides an overview indicating the relations of metadata types to content entities.

Table 1:
Use of different types of MP-AF metadata on the levels of content entities

	Preservation Object	Represen-tation	Essence	Bitstream
Provenance	×	×	×	
Context	×	×		
Reference		×	×	
Quality			×	×
Integrity		×	×	×
Authentication		×	×	
Fixity			×	×
Rights	×	×	×	

3.2 Metadata Structures for Specific Metadata Types

This section describes the metadata representations used for the specific types of preservation metadata, based on submissions received in response to the call for proposals issues by MP-AF in 2012.

Provenance metadata, item identification and description are supported by MPEG-21 DID as well as by the MPEG-7 Audiovisual Description Profile. Concerning technical metadata items, there are several minor gaps that can be filled by means of extensions to existing standards. Basic support for relationships between the items is provided by MPEG-21 DID. However, more details on relations between items are expected to be needed in some applications. MPEG-21 Digital Item Semantic Relationships (ISO/IEC 21000-3:2003/AMD 2) provides a set of relations between Digital Items (represented as an ontology), but not between Digital Items and other entities. The core entities of the MPEG-21 Media Value Chain Ontology (MVCO, MPEG-21 part 19) map well with the proposed core entities, and the subclasses could be supported as well. Basic relations between items are defined.

The preservation processes applied to Digital Items and Groups, the Activity and Operator entities are defined as part of the core MP-AF data model. These entities have been defined to ensure maximum compatibility with the corresponding entities in PREMIS, W3C PROV and BPMN (see section 4).

As part of the preservation metadata of an audiovisual content item, we aim to document the history of creation and processing steps applied, as well as their parameters:

- We describe what actually happened, i.e., a linear sequence of activities, maybe with the option to have a hierarchy for grouping activities.
- We define a set of specific types of activities in the model (e.g., digitization, with possible further specialization film scan), in order to improve interoperability between preservation systems.
- We describe the parameters of the activities, beyond a generic key/value structure. There should be a core set of well-defined properties, with type, and storing their values used when processing the item described. Of course, in addition there can be a key/value structure for supporting extensions.
- A specific set of these parameters are the description of tools/devices used in these processes, as well as their parameters.

The proposed submissions using MPEG-7 and MPEG-21 technology provide sufficient capabilities for item identification and referencing technical terms. The definition of reference vocabularies is out of scope of MP-AF. However,

where applicable a preferred vocabulary of terms is recommended (e.g., set of codecs currently under definition by EBU/AMWA FIMS[2], set of defects being defined by EBU QC[3]).

For fixity metadata, proposals have been made for temporally fine-grained checksums. This will enable better localization (and thus more efficient repair) of errors in bitstreams.

The requirements for metadata for integrity and authenticity are much less clear and homogeneous than for other types of metadata. Their definition is still an ongoing issue and might be deferred to a future version of the standard.

MPEG-7 part 4/AMD 1 contains description tools for audio quality. Extensions for MPEG-7 to describe visual and wrapper metadata have already been proposed as part of the standardization process. These MPEG-7 descriptors can be included in the MP-AF structure at the appropriate places. They address the requirements from current work on automatic quality analysis in the EBU QC working group and the FIMS QA group, which aims at specifying service interfaces for quality analysis tools.

For rights metadata, both MPEG-21 Rights Expression Language (REL, part 5) and MPEG-21 Contract Expression Language (CEL) / Media Contract Ontology (MCO) (parts 20, 21, semantically equivalent, but with XML and RDF/OWL representation respectively) will be supported. REL can be used if it is sufficient to represent the rights situation. In more complex cases, CEL/MCO can be used; the choice between CEL and MCO depends on whether the overall serialisation of the MP-AF metadata is in XML or RDF/OWL.

4 Relation to Other Data Models

Interoperability with other existing data models from different domains has been a core design principle. This core of the model is compatible with the Object-Event-Agent structure in PREMIS and the Entity-Activity-Agent structure in the recently completed W3C Provenance data model (cf. Moreau/ Missier 2013). The hierarchy of content objects has been aligned with different data models from audiovisual archives, but can also be considered as an extension to PREMIS. The compatibility improves with the changes planned

2 http://wiki.amwa.tv/ebu/

3 http://tech.ebu.ch/groups/qc

for the upcoming version 3 of PREMIS. This is important in order to support organisations holding some audiovisual content among others, but are not specifically related to the audiovisual domain. Figure 3 shows the mapping to the main entities of the PREMIS model.

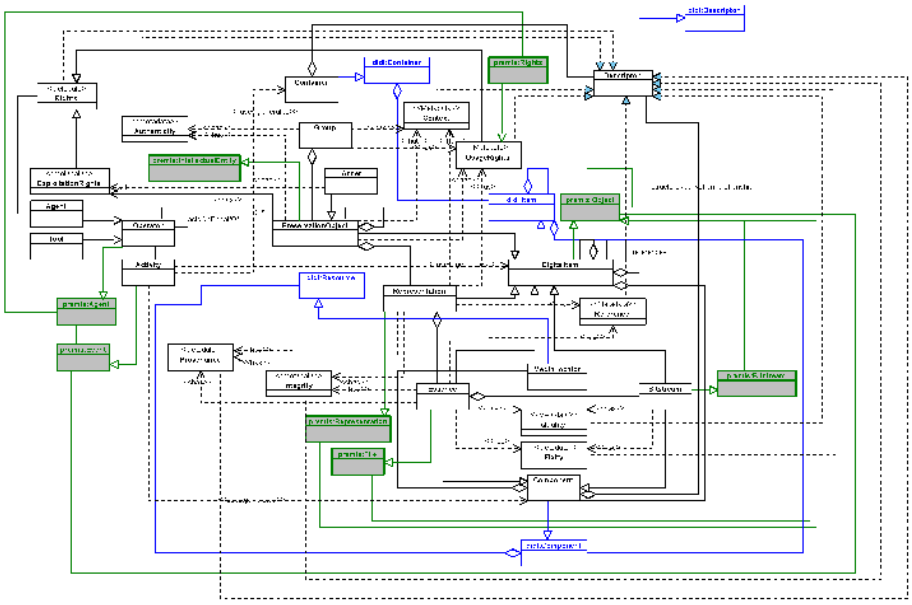

Figure 3 Mapping between MP-AF core entities and PREMIS entities; entities from PREMIS are highlighted

For the representation of processes and agents, the compatibility with Business Process Model and Notation (BPMN) (cf. OMG 2012) has been taken into account. In particular archives closely linked to media production institutions (e.g., broadcast archives, stock footage libraries) increasingly use service oriented architectures modelled using business processes.

5 Conclusion and Outlook

We have presented the current status of the work of the ISO/MPEG Multimedia Preservation group towards a standard for interoperable preservation metadata. The core data model has been established, and for many types of metadata the representations are defined. The main open issues concern integrity and authentication metadata, as well as specifying the minimal set of properties considered necessary for interoperability. In a later phase, conformance and validation procedures need to be defined.

At this stage, feedback from the different stakeholder in the preservation community on the draft is highly appreciated in order to shape the further development of the standard. The group expects to proceed to the next formal stage in ISO (Committee Draft) in early 2014, which would allow completion of the standard by 2015.

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