

AAF, MXF, XML... PUTTING IT ALL TOGETHER

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ABSTRACT

IT technology is becoming the inevitable trend in the broadcast and media market. The move to file-based production and management greatly increases the flexibility of the more and more software-based systems. In order to build on flexibility but avoid chaos, it is essential to put in place standards that address file-based exchange of information, both the audiovisual material and the associated metadata.

Enter AAF, MXF and XML... These acronyms are found in most products in the market today as synonyms of advanced file-based production and management technology, as well as openness to standards. But what purpose do they serve? Are these competing technologies? What is the relationship among them, if any? To make it even more difficult to understand, hybrid MXF/XML solutions are also arriving in the market everyday. And the new SMPTE S434 (MXF-XML) standard is expected to be published before IBC2006.

Adoption of these new technologies is happening so quickly, that most users and manufacturers are still struggling to understand how to use them. Therefore, this is the perfect timing to present this document. It identifies the purpose of each of these technologies and demonstrates how AAF, MXF and XML are actually complementary.

INTRODUCTION

Doubts on whether IT (Information Technology) would be suitable to provide the fabric on which to build the next generation of professional audiovisual media market systems are now dissolved. "IT-based" is now a selling point in the market. However, we are still at the very beginning, laying the grounds for applications to come.

As we move towards file-based production, the more important it becomes to define the basics, that is, the format of those files and streams. And this is of course the reason for the success of AAF, MXF and XML. These acronyms bring to the market the promise of true interoperable IT based technology and enhanced functionality, by putting together Essence and Metadata, two other keywords that come up in every text on the subject.

Essence usually means what is essential about the content, and in this market that means the actual audiovisual material. Metadata signifies data about data that is, data about the Essence. It includes a variety of data, ranging from the more technical such as timecode or video compression parameters, to the more abstract like titles or scene descriptions.

Metadata is key to this IT revolution, since it is the integration - and even synchronization - of this Metadata with the Essence that enables machines to automatically make decisions about received content, therefore automating processes and releasing manpower for the creative tasks. This is only possible if technical specifications are agreed upon, namely on how to represent such Essence and Metadata in files and streams (the term file will be used to mean both of these throughout the text) and hence the need for AAF Association specifications, SMPTE MXF standards and W3C XML recommendations.

A danger posed by IT is, however, the pace at which it moves. With technologies popping up every day around the globe pushed by the mass market, it is sometimes difficult to keep track of it all. Additionally, it is a well known fact that every time a new technology comes up, there are those that will use it for what it was designed for, and those that use it for everything else as well. For this reason, this document is intended to advise users on AAF, MXF and XML, and how to use but not abuse these technologies.

TECHNICAL OVERVIEW

Technical details are out of the scope of this document, but are covered in detail in available literature for AAF (1), for MXF (2) and for XML (3). However, this section will provide a quick overview, so that readers unfamiliar with these technologies are able to understand the remainder of the text.

Advanced Authoring Format - AAF

The Advanced Authoring Format, developed by the AAF Association (www.aafassociation.org), is a wrapper of Essence and associated Metadata designed for Post-Production interchange. It is not in itself a file format though. As displayed in Figure 1, AAF makes a clear distinction between Object Model (4) and Storage Layer.

The Object Model includes a Metadata core which sets out the structure of the content. It also includes additional Metadata that is more specific to Post-Production scenarios, although this separation may not be immediately apparent from the specification. Core metadata includes information such as number of tracks in the file, timecode discontinuities or Essence compression parameters, among other. The more Post-Production oriented Metadata includes, for example, effects and complex audio/video transitions.

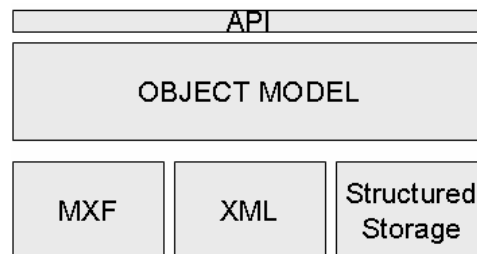


Figure 1 – AAF Object Model and Storage Layer

The covering of this kind of information leads to an extensive, and therefore reasonably complex, Metadata model (an expression that, for the purpose of this text, is used interchangeably with Object Model). By using UML (Unified Modelling Language) to specify such structure, the specification enables developers to easily map this into Object Oriented Programming language class models (such as C++). This provides an interface at the API (Application Programming Interface) level, which isolates developers from the actual format of the stored data.

The actual storage format for an AAF compilation is handled by the Storage Layer. Here, different storage formats can be used: Structured Storage (a well known storage format introduced by Microsoft Corporation that can wrap both the Essence and the Metadata), MXF (the SMPTE standard for Essence and Metadata wrapping) or XML (W3C

Recommendation that can be used for the Metadata representation).

Material eXchange Format - MXF

MXF stands for Material eXchange Format, and it is a SMPTE (www.smpte-mxf.org) standard file format. It is intended for the interchange of finished and almost finished audiovisual material and associated Metadata between different systems, inside the same organization or across organizations.

MXF defines the actual file format and bitstream syntax (5). Its core Metadata model is kept inline with AAF's core Metadata Model, described above, via a strong liaison between SMPTE and the AAF Association.

As for the Post-Production specific Metadata, it can be added as extensions to the core Metadata model. Therefore, in MXF there is a clear separation between what is core Metadata (actually called Structural Metadata in the specification), and what is Metadata related to a specific application area. Metadata for each area is expected to be defined as a plug-in into the Structural Metadata, therefore reducing file complexity and enabling configuration for different areas of the content lifecycle such as acquisition, archive and distribution, among others.

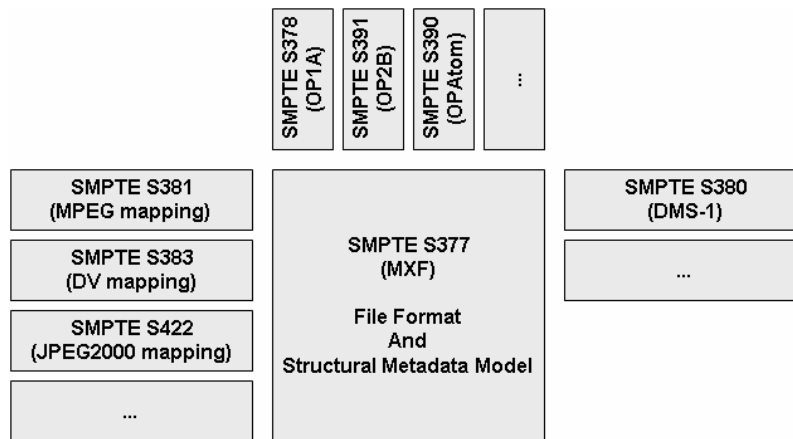


Figure 2 – MXF Standard Document architecture (not a complete document list)

Some of the application specific Metadata models are expected to become standardized as Metadata Schemes. At the time of this writing, DMS-1 (6) is the first one to have reached publication. However, MXF was also designed to support custom developed Metadata models, so users can add their own Metadata, according to their own models, to their MXF files.

The need for a flexible format, adaptable to several different scenarios in these different application areas, also led to a plug-in based architecture. This means the "MXF standard" is actually a set of standards as shown in Figure 2. The SMPTE S377 File Format document is referenced by:

- Essence Mapping documents – which define how to wrap each Essence format in MXF;
- Descriptive Metadata documents – which define Metadata extensions for different applications and scenarios (DMS-1 is a published example of such);
- Operational Pattern documents – which define how to configure MXF for different application scenarios.

eXtensible Markup Language - XML

The eXtensible Markup Language is a W3C (www.w3c.org) Recommendation that specifies a text based file format for encoding of data. Considering the two kinds of data primarily considered in this document (Essence and Metadata), it is important to notice that XML usage is relevant for the representation of Metadata alone.

It is foreseeable that, in the future, the meaning of the term Essence might be broadened to include data other than audiovisual material, which might actually be encoded as XML. But for the purpose of this document, whenever referring to Essence, audiovisual material will be meant.

XML encodes textual data in a way that is human readable but also machine readable and “understandable”. That is, data is marked with special tags that machines can interpret and react to, by performing specific tasks for which they were programmed.

As an example, data like “John 54” and “Mary 73” wouldn’t mean much to a machine. But something like “<name>John</name> <age>54</age>” and “<name>Mary</name> <weight>73</ weight >” would enable developers to build systems that use the XML tags in the text to figure out what to do with each data item.

In reality, once you start producing huge XML files, human readability no longer applies. But the widespread use of XML in the IT community today results in a variety of tools being available in the market to handle this data format, therefore reducing development time and costs. It is therefore no surprise that, as more and more IT technology gets used in the professional media market, more and more XML based technology finds its way in as well.

EXCHANGING

What is finished or almost finished material? And what is work in progress? In the end, in what was written above, this was the main difference in scope between AAF and MXF. Actually, the fact is that throughout its lifecycle, content is affected by a chain of events that gathers the work of different individuals, and often spans across multiple organizations. Having this in mind, it is obvious that one man’s finished work usually is another man’s input raw material.

Each human or system in the chain performs one or more operations - adding a contribution - and packaging the result for the next stage. From the point of view of that system or that individual, whatever is received at the input is raw data, and whatever is delivered at the output is finished or almost finished material. This is the model that gave birth to MXF and the reason for the “eXchange” term in MXF.

It should also be clear that, unlike AAF, MXF does not target a specific area. It is in fact a horizontal technology that provides the glue between different systems within an area, and also between areas.

As an example, in post-production, you can author your content with AAF and then package and exchange it with MXF. You can do this by rendering out of Post-Production the finished or almost finished version; or you can package in MXF the un-rendered AAF compilation. Here you can take advantage of the fact that you can store it as MXF, by writing the AAF

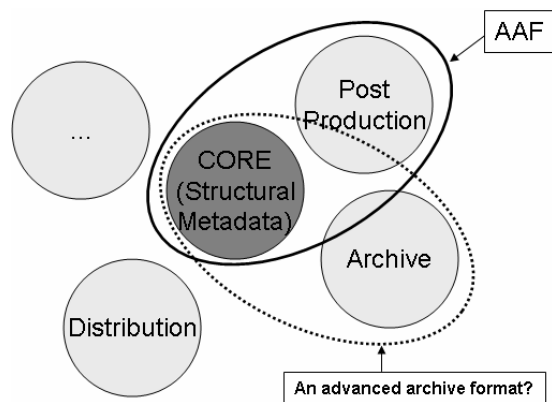


Figure 3

AAF Metadata Object Model scope

Core metadata as MXF Structural Metadata and the post-production Metadata part as extensions plugged in.

As shown in Figure 3, in a completely different application, you could also have your MXF files including Structural Metadata plus Descriptive Metadata plugged-in (using SMPTE DMS-1 for example) and call it Advanced Archive Format.

MXF will keep evolving as more and more different kinds of Essence, Metadata and other kinds of data need to be exchanged using this technology. This effect is being amplified as MXF expands to new areas as well. After all, MXF functionality is generally applicable to creation, management and distribution of content and, although MXF started in the Broadcast market, it is quickly spreading out to other areas, such as Digital Cinema or Military applications among others.

AUTHORING

Authoring applications can become very complex very quickly, as we move from using simple editing with fades, to using complex effects and transitions, to integrating ground breaking technologies on the ever evolving synthetic image production areas, such as 3D animation for example. Additionally, collaborative authoring is now more and more a requirement, making it increasingly important to enable the interconnection of different tools, from different vendors, often even originating from disparate industries. This is pushing the needs for standard interface definitions, and AAF and MXF play a huge role here.

Each member of a team working on a production can provide a contribution by authoring in his or her favourite tool, packaging with MXF and sending it as finished or almost finished material, as set out above. We can see this as a loose integration of authoring tools. This is becoming the usual scenario, as authoring becomes more spread out even across different organizations collaborating in complex projects.

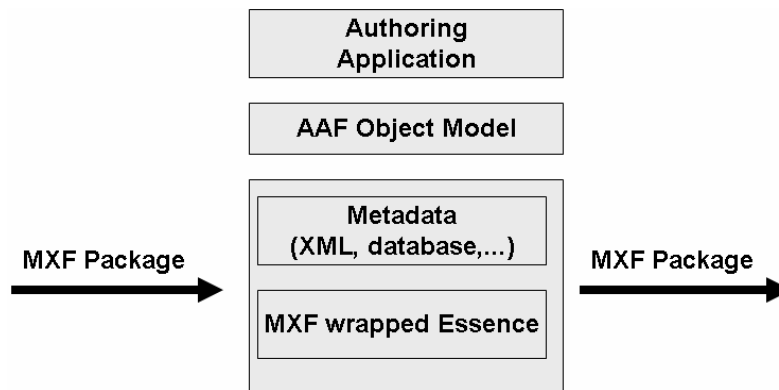


Figure 4 – Unpacking, authoring, re-packing, exchanging...

But once the MXF package from the scenario above gets to the next authoring tool, it will be opened and its contents extracted into a format that is natively easier to handle by the tool from that specific vendor. Usually this will mean the Essence will still remain wrapped in the MXF file format, taking advantage of the Essence handling mechanisms provided by this format (such as Index Tables for optimization of random access). However, the Metadata and all other kinds of data will be extracted, and represented in a way that provides maximum processing efficiency for the specific application. In a standalone application this will usually be XML. In more complex applications, supporting several users working on the same work item concurrently, the Metadata will probably be fed to a database, making it

easier to be searched, browsed and managed.

Therefore, there is no single solution that will meet all requirements of every application scenario. This is the advantage of the clear separation in AAF between Object Model and Storage layer. Manufacturers of Authoring tools can develop their systems according to a compliance interface which is the AAF Object Model (which in the end defines the Application Programming Interface), and then deploy their systems with different storage formats depending on the scenario.

In the future, we will see a move towards the integration of the AAF Object Model - designed for the Post-Production area - with other Object Models from new technologies making their debut in this area. This will be the reflection of the users need to take advantage of a variety of innovative authoring technologies and tools, in order to leverage their creativity and differentiate their products (their content) in their market.

EXCHANGING IS HORIZONTAL

It follows from the above that MXF is the solution for exchange, making it a horizontal technology, and AAF is its vertical complementary technology in the Post-Production area. This becomes even more apparent if we have a brief look at some examples on what is happening in the market today, and not only the broadcast market.

Production

MXF is now the format of choice right from the beginning of the content lifecycle. All major camera manufacturers in the broadcast market now produce MXF right at the camera. Material is packaged in MXF and stored in disks or solid state based media. If we look inside that storage media, the material is wrapped in MXF but the Metadata is usually partially in the MXF files (the Structural part) and partially in accompanying XML files (Storage and Descriptive related Metadata).

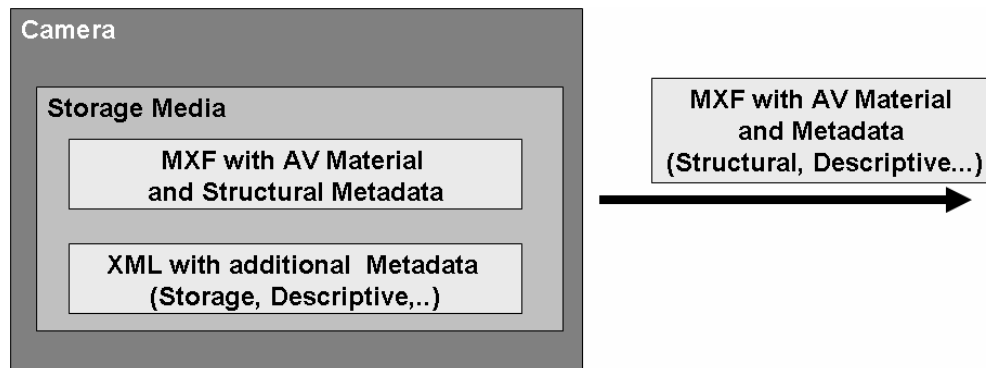


Figure 5 – MXF used from start of the content lifecycle

Storage Metadata helps managing the way the MXF wrapped audiovisual material gets stored on the physical media. Examples are information on partitioning of the recorded clips in several data chunks, or MXF information caching for performance enhancement. Descriptive Metadata enables logging of context information, such as general descriptions or points of interest in the content.

Just as in the Authoring section above, also in this Production scenario some of this storage Metadata is no longer needed, once the content leaves the storage media to be delivered to

the next system in the chain. However, some of it makes sense to be sent in the package. Therefore, tools that allow users to package in MXF some of the Metadata in those XML files are making their debut in the market today. That Metadata is usually mapped into standard MXF Structural Metadata, plus DMS-1 Metadata, plus extensions. But the technical details are outside the scope of this text.

Digital Cinema Distribution

D-Cinema is yet another example of MXF's horizontal nature. The major studios in Hollywood published in 2005 their DCI specification (6) laying out the model for Digital Cinema Distribution. Distribution packages - called DCPs - will be the way to distribute movies and, if you look inside those DCPs, again MXF is the format of choice to carry picture and sound information. Also, again XML is the format of choice to add the Distribution specific information (Metadata).

ENTER XML

It is interesting to note how XML naturally made its way into this text as AAF and MXF was being discussed. It was just natural. In the end, XML is just another encoding format for data, but it happens to be a widely used one, therefore making itself the usual choice for general purpose applications. Here are some applications where XML is proving itself useful:

- Management information – usually the kind of information that is used to manage MXF files, as in the Production and D-Cinema distribution scenarios above;
- Alternative representation for interfacing – in order to facilitate the adoption of IT in the professional media market, one needs a quick way to bring IT XML-language-speaking manufacturers up to speed with professional media technologies such as AAF and MXF. XML provides an interesting alternative representation for Metadata that is easier to understand and process by newcomers¹;
- Migration – for applications where MXF is used as a channel to tunnel XML documents generated by legacy systems. In this case both ends of the exchange channel need to understand both MXF and XML, which may in some cases increase complexity and endanger interoperability. Therefore it is highly advisable to always consider mapping of information into the MXF Metadata model;
- Exchange of complex data structures – some data structures are so specialized and/or complex, that the cost of expressing such information in the MXF Metadata model is higher than the cost of expressing it in XML, and having decoders handle that format as well. Nevertheless, it is still highly advisable to as much as possible rely on XML based standards in this case.

Regarding the carrying of XML data in MXF, it needs to be noticed that this is not a matter of merely dumping the XML documents in the middle of the MXF file. MXF does provide mechanisms that enable one to establish links between the XML information, the regular MXF Structural Metadata, its extensions and the actual Essence inside the file; and all this with frame accuracy. This opens doors to new applications that are starting to appear in real world systems, at the time of this writing.

¹ Specifically targeting this, at the time of this writing SMPTE is finalizing the development of SMPTE 434 (MXF-XML), a standard for the XML representation of MXF Structural Metadata and extensions. Examples of MXF-XML applications are the interfacing of MXF Metadata to databases, or graphic user interface development using off-the-shelf web development tools.

CONCLUSIONS

AAF, MXF and XML are complementary technologies and provide the foundation of the new file-based production paradigm.

MXF is a horizontal technology devoted to exchange and its applicability spans across all stages of the content lifecycle. AAF is its complementary technology that targets the post-production environment, and isolates authoring tools from storage and management details. The professional media market needs both AAF and MXF in order to satisfy its complex requirements. It also needs a way to welcome other IT technologies that provide improved functionality and cost reduction. As a result the XML language - widely used in the IT world - is increasingly becoming integrated with both AAF and MXF.

The future will see AAF relating more and more to other Object Models in the authoring arena, as Post-Production continues to integrate alternative tools in its workflow. The amount and variety of information will increase dramatically.

The same will apply to all other areas. Cameras will produce more (Meta)data immediately at capture time; archive systems will integrate more Metadata enhancing search efficiency and content re-purposing; and organizations will pursue multiple distribution channels, opening the door for innovative applications and new business opportunities.

As a horizontal technology, MXF (and its integration with XML) will play a key role by providing packaging and exchange platform that will enable optimized workflows to be established. With MXF, each step in the chain now has the mechanism to receive all needed input, and deliver its contribution to the output in a standard way.

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