Tying it all Together

— a watershed moment in the media industry

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In July of 1998, the joint SMPTE / European Broadcasting Union (EBU) Task Force for Harmonized Standards for the Exchange of programme Material as Bitstreams published its "Final Report: Analyses and Results". Now some 13 years later, the basic framework outlined in this report is becoming a reality. However, more than this, the framework allows innovative media companies and manufacturers to expand the power and possibilities of the framework well beyond what was envisioned when the report was published.

This article — first published in the March 2012 edition of the SMPTE *Motion Imaging Journal* [1] — connects the dots among (i) serial digital interface (SDI), (ii) image compression, (iii) the invention of the Advanced Authoring Format / Material eXchange Format (AAF / MXF) data model, (iv) the MXF wrapper format, (v) the subsequent development of AS-02, AS-03 and other MXF application specifications, (vi) developments in high-speed networking technology and network security, (vii) the SMPTE 2022 Standard for Professional Video over IP transmission, (viii) the recent activities of the Hollywood-based ETC's Interoperable Mastering Format (IMF), which has recently moved into SMPTE, and (ix) the Advanced Media Workflow Association / European Broadcasting Union (AMWA / EBU) Task Force on the Framework for Interoperable Media Services (FIMS), concentrating on service-oriented media workflows.

I posit that we are at a watershed moment in the industry, which will create new opportunities, and even perhaps new media businesses that do not exist today.

Introduction

In the early 1990s, many in the media industry became concerned about the changeover from analogue to digital video. Specifically, they were concerned that the industry would become deadlocked as several competing, non-interoperable technologies were developed. SMPTE and the European Broadcasting Union (EBU) created a joint effort to identify areas where standardization was required. The group held several face-to-face meetings and published its final report in July of 1998 [2]. This far-reaching report called for standardization of digital video, but it also called for stand-

1. SMPTE Motion Imaging Journal: http://journal.smpte.org/
2. Joint SMPTE/EBU Task Force for Harmonized Standards for the Exchange of programme Material as Bitstreams published its *Final Report: Analyses and Results: July 1998.* http://tech.ebu.ch/docs/techreview/ebu-smpte-tf-bitstreams.pdf

ards in a number of other areas, including standards for the exchange of content and metadata in a simple wrapper (now MXF), and in a more full-featured wrapper for edit interchange (now AAF). Furthermore, it explored standardization at the system layer, allowing interoperable control architectures.

In the years since the Task Force report was published, SMPTE has engaged in many efforts directly related to the report. Trade associations such as the Video Services Forum (VSF) [3] and the Advanced Media Workflow Association (AMWA) [4] have served as incubators and discussion groups for the development of input documents to SMPTE.

Key enabling technologies

Clearly, development of the serial digital interface (SDI) for video has been a key enabling technology because, without it, the move from analogue to digital video would have been delayed for months, perhaps years. From where we sit now, it is hard to know how long it would have taken for a dominant technology to appear, and how many millions of dollars would have been spent on equipment that would have soon become obsolete.

Taken together, the collective improvements in computer processing power, reduction in the cost of storage, the increase in the density of storage, the increase in networking speeds, and the ubiquity of internet protocol (IP) should be considered key enabling technologies for the media industry. The recent focus by mass-market computer software and hardware vendors on consumer video as the "next big thing" has driven down costs and driven up the capabilities of generic computer platforms in a way that the professional media industry never could have done. The ramifications of these key enabling technologies have yet to be fully recognized.

What problem are we trying to solve?

The question *"What problem are we trying to solve?"* is a frequent refrain at SMPTE technology committee meetings. So, in pulling a number of disparate threads together, perhaps it would be best to start with a description of the problem.

Media decomposition

In the beginning, there was film — and film was easy [5]. You had a sequence of pictures captured on the film, and you had sound. You may have had to deal with whether the sound was mag stripe or optical, but other than that, film was pretty much plug-and-play (load and play, actually). Film came in a metal can, and affixed to the can and the film reel, there was a paper label that told you pretty much everything you needed to know. All a projectionist at a theatre or a telecine operator at a television station had to do was verify that the information on the label matched the movie to be played, load the film, and put the projector in remote so that it could be started at the appropriate time.

3. For more information on the Video Services Forum see **http://www.videoservicesforum.org/**.
4. For more information on the Advanced Media Workflow Association see **http://www.amwa.tv/**.
5. Film was actually very hard! One of the first tasks the SMPE (the Society of Motion Picture Engineers, a precursor to the current SMPTE) took on was the standardization of film. Without this effort, film technology would have wallowed for many years. For an excellent description of these early standardization efforts, see *Technological History of Motion Pictures and Television: An Anthology from the Pages of the "Journal of the Society of Motion Picture and Television Engineers"* by Raymond Fielding (hardcover, Jan. 31, 1980).

Along came videotape — and videotape was easy [6]. As with film, you had a tape in a box. The box and the tape both had a label, and there was usually a piece of paper in the box. Once again, all an operator had to do was to verify the label with the information on the log, load the tape machine, and put the machine in remote so that it could be started at the appropriate time.

Then along came media files — they were not quite as easy. The difficulties pretty much started and ended with the codecs used to create the files. Early on, just about any video file available was compressed, if for no other reason than that the sheer size of uncompressed files overwhelmed just about every aspect of computer technology. Because codecs are software (even when instantiated in hardware), and because even early compression methods allowed a very large number of choices to be made in coding the material, interoperability issues were rampant. Along with all the codec interoperability issues, there was also a huge knowledge gap. People who had worked with video all their lives suddenly found themselves confronted with a myriad of configuration parameters for coding and decoding, and misconfiguration was the order of the day. Of course, even if you were able to properly decompress a file, nothing would help you if you were trying to play back video on a system that could not understand the original digital video format.

Along with files came some new terminology. We were no longer dealing with a cassette or a reel of film. In fact, there was a separation of the physical media from the content it contained. The essence on the tape became an Asset: Content, Essence, or in some circles, Media. Metadata became a popular topic. We started hearing about data models. These were new concepts and they took some getting used to.

Fortunately over time, things have got much better. For the most part, video engineers now understand how to configure codecs to get reliable results. Most people know that you must have a destination device that understands the source video format if you want to get pictures at the far end, and, for the most part, manufacturers have done a good job of providing interoperability modes on their codecs that reduce incompatibilities. So, while the terminology is still new to many of us, we are getting more comfortable with the new vocabulary that files brought with them.

The first indication that difficult problems could occur, came with digital versatile discs (DVDs). The good news was that codec interoperability was good because the DVD specification constrained the codec options. The bad news was that the DVD contained more than one video and audio combination. For example, a DVD might contain a video track and the English version audio track. It might also contain a French language audio track. Furthermore, it might contain Portuguese subtitles, a director's commentary audio track, outtakes from the movie, photographs of original movie sets or artefacts, and so on. The DVD specification [7] includes instructions for how to lay out these additional components on disk and how to pull them together for presentation to the viewer. Put simplistically, the DVD wrapper is standardized.

Many versions, many elements

A single DVD contains many individual elements. The DVD also contains instructions on how to combine these elements to render a particular version of a movie to the viewer. The DVD highlighted a problem that the Hollywood community had been struggling with for some time.

Humans tend to think of a movie as one particular thing. Take *Avatar,* for example. Most people in the industry have seen this movie, but it turns out that there are more than 120 different versions of *Avatar*, and these 120 versions are composed of hundreds, if not thousands of elements — video

6. Videotape was actually a little tricky too. Of course you had the different video standards, NTSC (National Television System Committee), PAL (Phase Alternating Line), and SECAM *(Séquentiel couleur à mémoire)*, and you also had some incompatibility issues within a format (Sony vs. Ampex 1", for example). However, by and large, video tape was comparatively straightforward.
7. DVD specifications are maintained by the DVD Forum (**http://www.dvdforum.org/**) as "books" such as the DVD-Rom Book, DVD-Audio Book, etc.

tracks, audio tracks, subtitle streams, natural sound tracks, computer-generated imagery (CGI) elements and so on. Studios are faced with the daunting task of keeping track of a growing number of elements as the number of target platforms, such as mobile devices, desktops and tablets continues to grow. Keeping track of these elements, and keeping them properly associated, is a serious problem.

The Interoperable Mastering Format

Hollywood responded to the problem by forming a group under the Entertainment Technology Center (ETC) [8]. The ETC began working on the *Interoperable Mastering Format* (IMF). At its heart was the concept of using a common wrapper to organize all the elements that comprise the different versions of a movie, and to then use technology to render a specific version of the movie on demand. Elements are collected into bundles, and bundles are used to create versions.

The ETC has concluded its work and has produced an input document that is currently under consideration within the SMPTE 35PM50-IMF Working Group, chaired by Annie Chang, for development as a SMPTE standard.

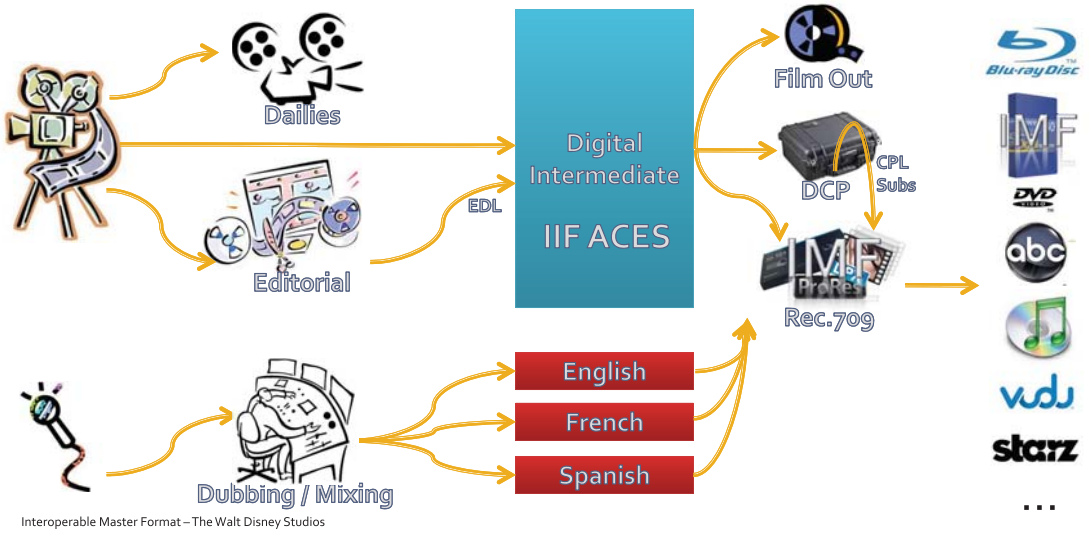

Figure 1
A typical movie workflow and the Interoperable Mastering Format *(Figure courtesy of the Walt Disney Studios)*

Fig. 1 shows that, in the IMF typical workflow use case, content is acquired via the film camera, microphones, etc. Through the Digital Intermediate process, the finished film or Digital Cinema Package is created. However, note that in addition to the rendered film and the DCP, an IMF wrapper bundles all the elements for the different versions together. The bundle is then used to create different versions of the movie on Blu-ray, DVD, for television, etc.

MXF — the solution to everything

In 1998, the joint SMPTE-EBU Task Force for Harmonized Standards for the Exchange of programme Material as Bitstreams [1] report identified the need for a simple wrapper format. The Material eXchange Format has emerged as the simple standards-based wrapper [9].

8. Entertainment Technology Center: **http://www.etcenter.org/**.
9. QuickTime is also frequently deployed in professional applications. The specification is owned by Apple (**http://www.apple.com/quicktime/**).

As *Fig. 2* illustrates, the purpose of an MXF wrapper is to apply some rigour to the location and identification of various components of a finished programme. It also provides a common way of establishing the timing relationship between different components of the finished programme, e.g., video/audio synchronization.

Unfortunately, many problems that seem simple at first, become more complex as you get into the details. Over time, the MXF specification [10] became increasingly involved as it expanded to accommodate a number of different scenarios. In the end, the specification grew to more than 600 pages. As a result, interoperability issues surfaced as manufacturers implemented the written document in different ways. While MXF ended up being very full-featured, manufacturers found it difficult to achieve reliable interchange.

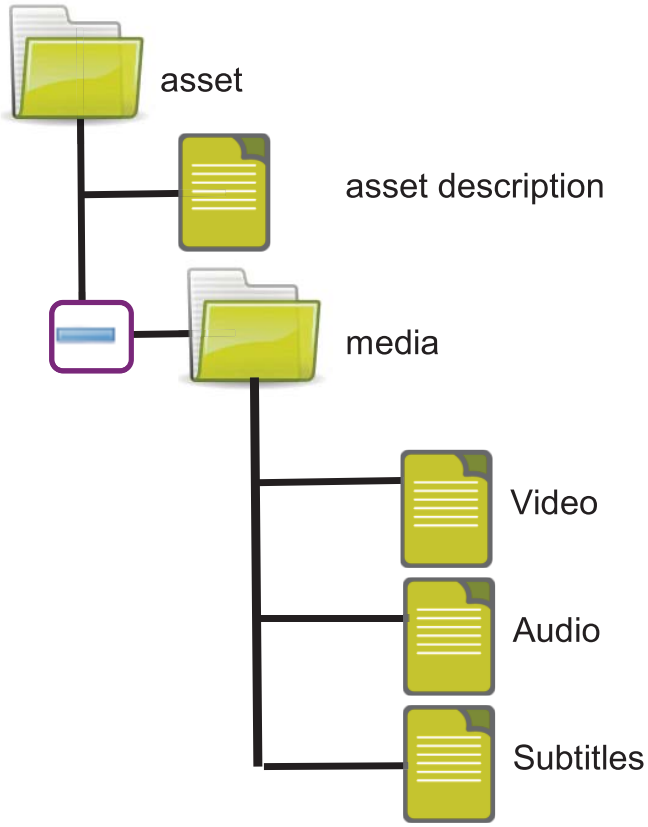

Figure 2
An MXF wrapper provides a standardized way to wrap together different components of a finished programme *(Figure courtesy of Amberfin)*

Application specifications

Application specifications (AS) have been created by the AMWA to increase interoperability of MXF files in specific areas. An AS may require, for example, that although there are five different places where you are allowed to put a time code in an MXF file, only put time code here. Application specifications may also put limitations on essence coding, for example, stating that only MPEG-2 coded at rates between 5 and 50 Mbit/s with a group of pictures (GOP) of 15 are allowed. An AS may also state that the only acceptable reference to an external piece of content is a Universal Resource Identifier (URI) as specified by the W3C. So, as *Fig. 3* shows, an AS may draw on a number of different standards, referencing only the relevant parts, and then be very specific about how those parts are to be used.

One other key concept behind AS is “no new invention”. This simply means that, in creating application specifications, we try hard to use existing specifications rather than create new ones.

AS-03 — MXF for Finished Programmes

AS-03 was sponsored by Jerry Butler and the Public Broadcasting Service (PBS). Butler’s user requirements were clear: Butler wanted to define an MXF wrapper containing a single standard definition finished programme. Butler wanted to be able to wrap that programme in AS-03, have the file land on servers at PBS affiliate stations, and have servers at those locations reliably retrieve the metadata and play the content. Butler and a dedicated group of vendors worked to scale down the MXF specification and, importantly, to constrain the format of the video and audio allowed in the AS-03 file [11].

10. The core specification for MXF is SMPTE ST 377-1:2009: Material Exchange Format (MXF) File Format Specification, available from http://www.smpte.org/. Implementers may also find SMPTE EG41: MXF Engineering Guide useful.

11. It is important to note that nothing in the MXF specifications constrains the format of the video and audio wrapped in the MXF file. Therefore, it is possible to be able to understand the content of the MXF wrapper but still be unable to view the essence due to video/audio codec interoperability issues.

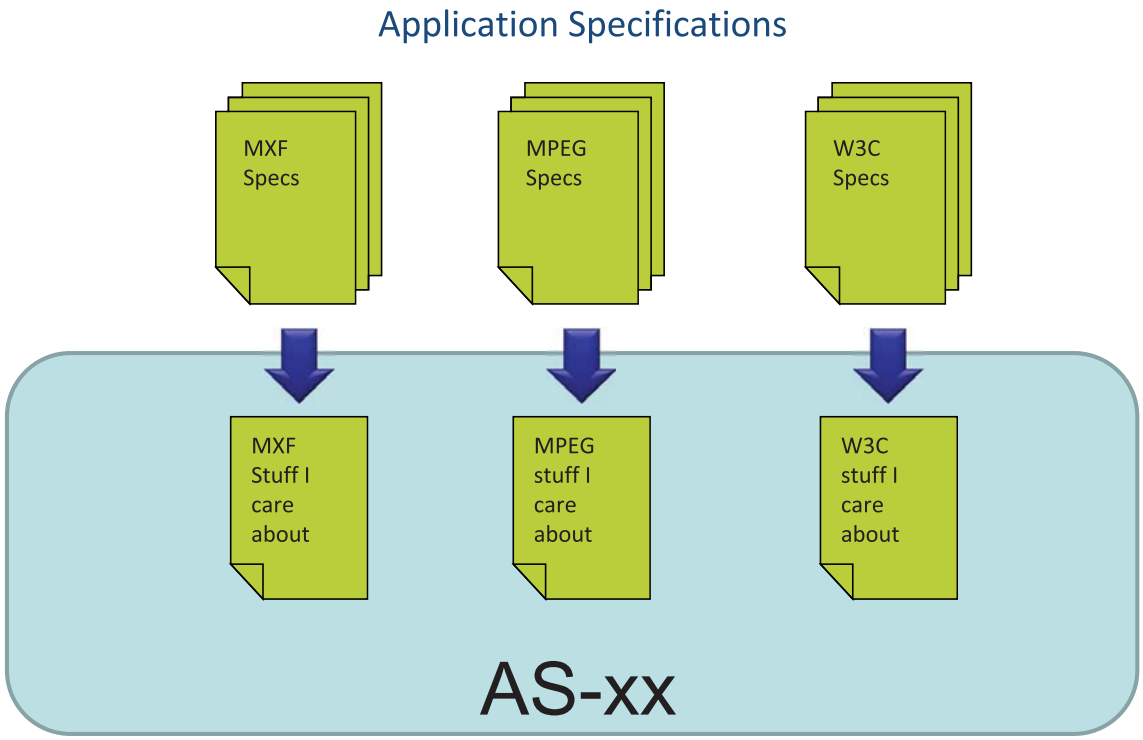

Figure 3
Application specifications draw from existing standards. They state what parts of the standards to use, and how to use them.

AS-10 — MXF for Production

The production community had a set of user requirements related to file-based production. These requirements were generally met by something known in the industry as SMPTE RDD-9 [12]. Unfortunately, RDD-9 was not specific enough to ensure reliable interchange of essence and metadata. A number of users and manufacturers decided to create a new AMWA Specification which was sufficiently detailed to increase interoperability in the MXF production domain.

AS-11 — MXF for Contribution

Butler had a very specific set of user requirements. This allowed him to get results relatively quickly, but it meant that AS-03 was not necessarily going to meet every requirement for finished programming. In the UK, the Digital Production Partnership (DPP) [13] had a requirement to increase interoperability for finished programming, but their user requirements were different. First of all, they required data rates up to 100 Mbit/s. Also, they needed a metadata set which would meet the requirements of UK broadcasters. MXF for Contribution meets the requirements of this market.

AS-12 — MXF for Commercials

There has been a need for a common commercial file format for quite some time. Demand has been growing. One can imagine that the only difference between an AS for finished programmes and an AS for commercials would be the addition of “digital slate” metadata. This is exactly what AS-12 does — it expands the AS-03 specification to include metadata identifiers, which can be used to uniquely identify commercial content. AS-12 will work with any commercial identifier, but in the first instance, it is designed to work with Ad-ID.

12. SMPTE RDD 09-2009 MXF Interoperability Specification of Sony MPEG Long GOP Products.
13. DPP: **http://www.digitalproductionpartnership.co.uk**.

At the time this article was written, AS-02, AS-03, AS-11 and AS-12 were completed AMWA Specifications available for free download at the AMWA website [14]. AS-10 — MXF for Production is in its final draft form. *Table 1* summarizes some of the key features of several AMWA Application Specifications.

Table 1
Some common restricted MXF parameters per application specification *(Table courtesy of Al Kovalick)*

Restricted feature	AS-03	AS-10	AS-11	AS-12
Application domain	Programme delivery	Production	Contribution	Advert delivery
Video bitrate	SD/HD 5-50 Mbit/s	(depends on codec)	HD@ 100 Mbit/s	SD/HD 5-50 Mbit/s
Codec format	MPEG-2, H.264 LGOP	MPEG-2 MP@HL, MPEG-2 422P@HL MPEG-2 MP@H14 LGOP	AVC-Intra	MPEG-2, H.264 LGOP
MXF pattern	Op-1a	Op-1a	Op-1a	Op-1a
Audio channels	Up to 16	2 to 8	Up to 64	Up to 16
Metadata "slate" scheme	DMS-AS-03 (programme slate)	TBD	DMS-AS-11-UK/DPP (digital production project specific)	Ad-ID based slate metadata
Closed caption	CEA 608/708	CEA 608/708	CEA 608/708	CEA 608/708

The media factory and AS-02

Coincident with development of the task force report, many media companies began to face the challenge of providing content to any platform, anywhere, through any distribution medium. The old way of creating one stove-pipe workflow to serve one particular output (say a broadcast network stream) was under increasing pressure. While media companies had frequently distributed content to cinemas, broadcast networks and to other stations via syndication, it was in the early 1990s that we began to see the need to feed the web, mobile and other outlets. This was seen as an opportunity to monetize content through "another antenna". Unfortunately, it was extremely challenging to build a new "channel" at a cost that would not sink the nascent business opportunity. At that time, it took a certain base level of infrastructure to create a 24-hour stream of programming, and although technical people are actually quite creative, costs could only be reduced to a certain extent. At the same time, demands for new streams of content continued to increase, and media companies had no alternative but to figure out how to meet these new demands, even if the revenue streams from some of these ventures were small to nonexistent. If there was a way to efficiently repurpose content, then maybe these new demands could be met in a cost-efficient way.

Ian Wimset and the people at Red Bee Media [15] came up with a simple diagram *(Fig. 4)* that illustrates the concept of a media factory.

The media factory, at the centre of *Fig. 4* produces outputs such as linear television channels, finished programmes, promotional items, and electronic programme guides using inputs such as programmes, scripts, schedules, and graphic elements based upon orders, which may come in from a

14. Completed AMWA Specifications are available at **http://www.amwa.tv/**. Test utilities and golden files are available to AMWA members.

15. Red Bee is one of the origination facilities for the BBC in the UK.

variety of sources in a number of different formats. The media factory uses services such as transcode, store, package and conform, in order to render the finished outputs.

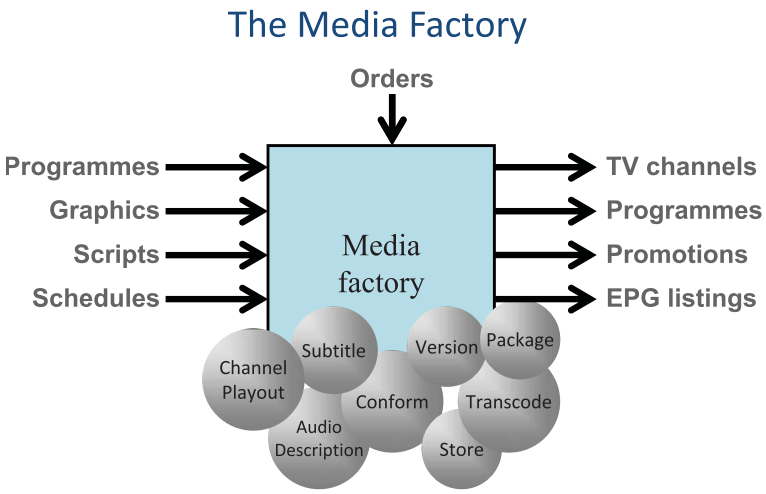

Figure 4
A media factory processes inputs using services to produce outputs according to orders *(Figure courtesy of Red Bee Media)*

AS-02 — MXF for versioning

If you are going to use a media factory to create many different versions of a programme, it would be helpful to have a wrapper that bundles together all the different elements used to create the different versions. You may recall that the IMF effort originated in Hollywood to allow studios to keep track of movie versions.

AS-02 — MXF for Versioning [16] has been created to allow content owners to use a media factory to render different versions of content for different platforms at a lower cost. One can easily see how a media factory could use an AS-02 file to create a finished programme wrapped as an AS-03 or AS-11 file.

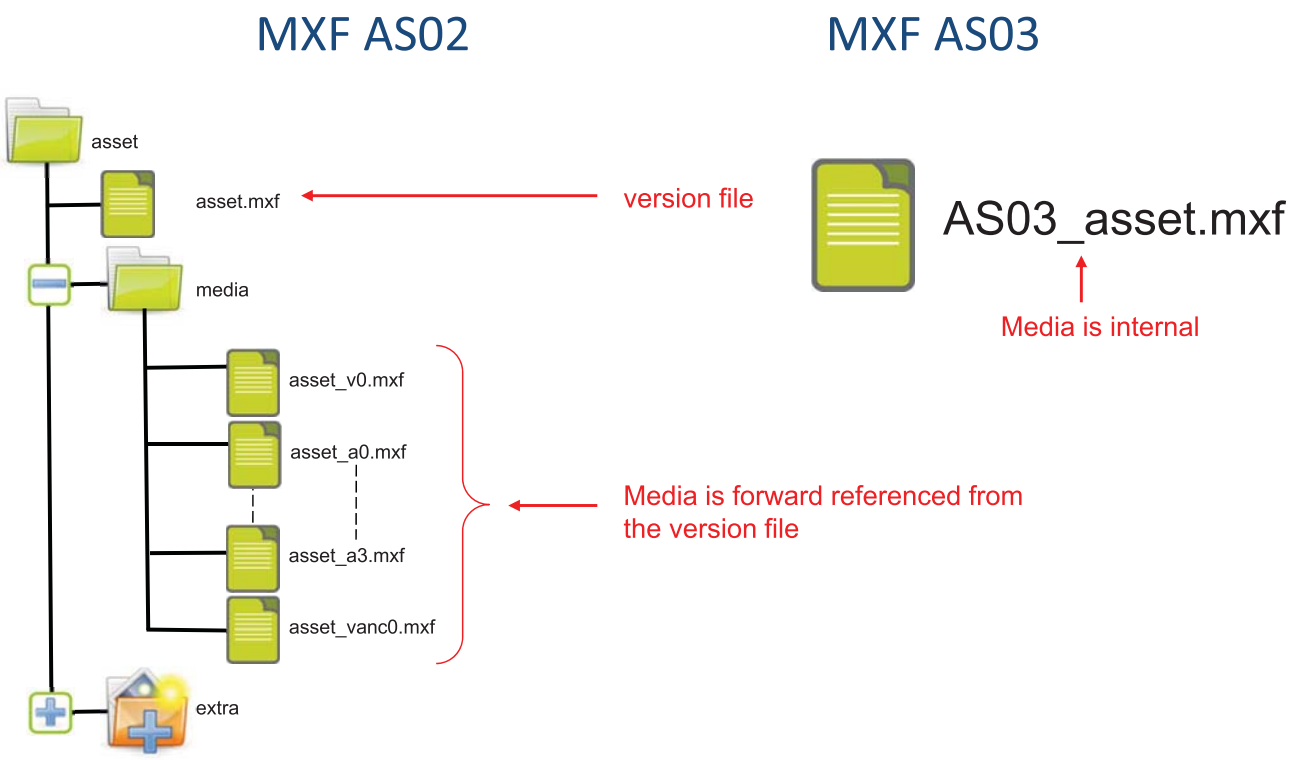

Figure 5
An AS-02 file contains instructions that can be used by a media factory to render a complete programme as an AS-03 file *(Figure courtesy of Amberfin)*

Fig. 5 shows that an AS-02 file can contain a document called `asset.mxf` which contains instructions that tell a media factory how to combine different video and audio tracks to create a particular version (say the English pre-watershed television version) of a programme. This programme can be wrapped as an AS-03 file for distribution to affiliate stations.

16. AS-02 — MXF for versioning specification available at http://www.amwa.tv/.

Facilitated media workflows

Regarding IMF and AS-02, there is strong alignment at the wrapper level. In fact, the AMWA has contributed the draft AS-02 specification to the SMPTE IMF group for consideration as they develop the IMF wrapper. The committee will make the ultimate decision as to where AS-02 and IMF are aligned, but there is strong industry consensus that the two wrappers should be similar.

One can imagine a media ecosystem where IMF is used to create finished AS-03-wrapped programmes, or where a movie studio is requested to send an AS-02 bundle of a movie to a downstream facility. That downstream facility could then use a media factory to create its own AS-03-wrapped finished programmes, based upon the AS-02 content it received.

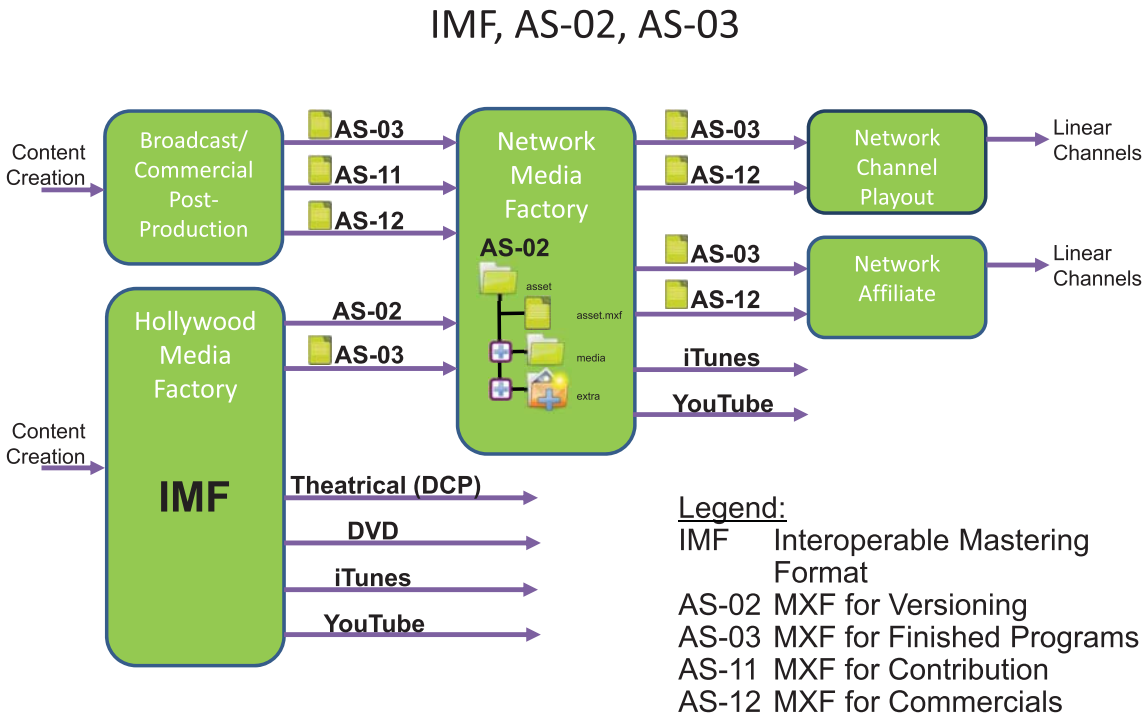

Figure 6
Putting it all together — IMF, AS-02 and AS-03

Fig. 6 illustrates the complete ecosystem. On the left, content is created either in the broadcast / commercial environment or by the Hollywood creative community. The content then enters post-facilities or a Hollywood creative process. As discussed previously, Hollywood needs to feed many different sources, including theatrical, television, DVD, iTunes and YouTube. A television network has similar outputs as well. Media factories allow Hollywood and television networks to render finished versions of movies, programmes, commercials or interstitials using harmonized MXF metadata wrapper structures. These files may be exchanged with media partners either wrapped as finished programmes, or as individual elements along with instructions about how to render these elements into particular versions.

Application specifications seem to be increasing the interoperability for both essence and metadata. MXF is gaining wide adoption as the preferred interchange format for professional media. Finally, IMF and AS-02 are well aligned at the wrapper level, and there is a commitment to support the vision of media factories in both the film and television environments.

However, there is also bad news — file formats and common wrappers are necessary, but not sufficient to build workflows in the real world.

Media services — a key component of media factories

Unfortunately, when one sets out to build real media factories, one quickly finds that they are complex. In fact, it is almost impossible to build these facilities using traditional pipeline processes

because of this complexity and the fact that the workflows are highly variable. Also, as *Fig. 7* shows, even in a simple system, the number of custom interfaces becomes unmanageable (interfaces are shown in yellow).

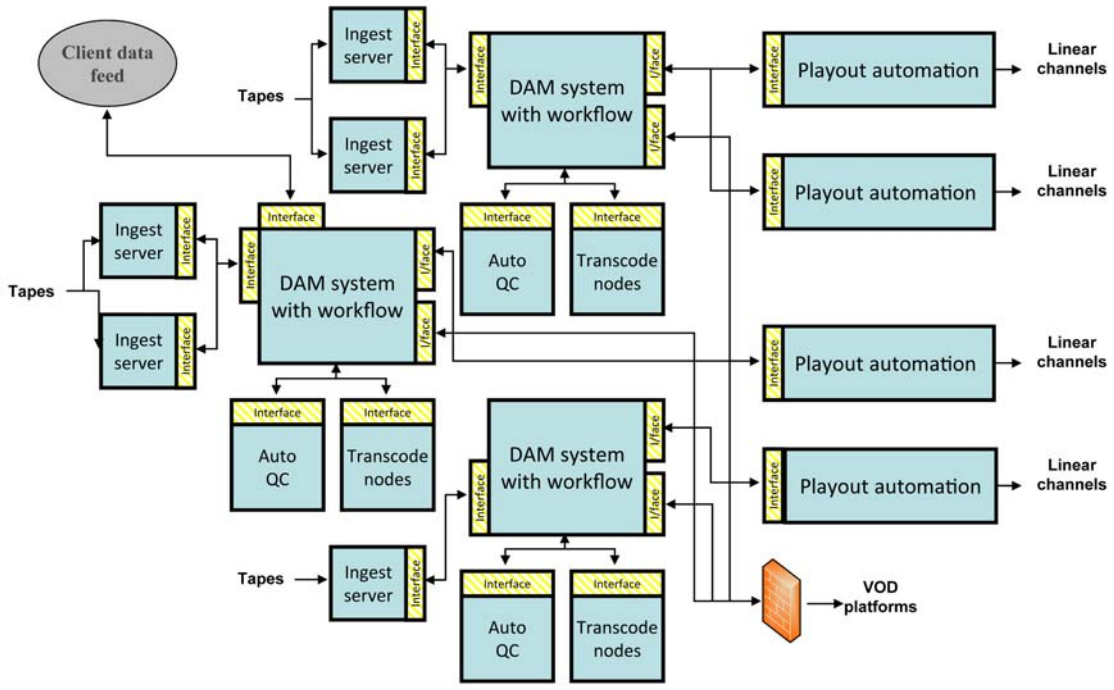

Figure 7
As media factories grow in complexity, the number of custom interfaces becomes unmanageable *(Figure courtesy of Red Bee Media)*

The Framework for Interoperable Media Services (FIMS) is a project co-sponsored by the AMWA and the EBU.[17] The goal of the first phase of this project is to produce a harmonized framework for media services and to develop specifications for three common media services — capture, transfer and transform. It is envisioned that additional media-service definitions will follow.

Under the FIMS framework, *Fig. 8* shows that media workflow is abstracted from Digital Asset Management (DAM) systems. A workflow orchestrator communicates with DAM systems, capture services and transcode services through a common service layer. A common framework and standardized interfaces simplify the integration. Legacy systems can be wrapped or adapted to the FIMS framework.

FIMS is in the early stages, but it provides one solution to the difficult issue of complex, tightly integrated media services.

Software as a service

The concept of video transcoding and other media-specific functionality offered as a service has been presented above. Offering services across a network is becoming commonplace. Software as a Service (SAAS) is a relatively new concept in the media industry.[18] The basic idea is that software can be offered across the internet, accessed through a web browser. Accessing software through a web browser means that the software can run on virtually any computer. Consider video editing software.

17. More information on FIMS is available at http://wiki.amwa.tv/ebu/.
18. For a good overview of Software as a Service, see “Software as a service overview” by Infoworld.com at **http://www.youtube.com/watch?v=kGUPSvswmY0**.

Currently editing software is loaded on to a local workstation, content is ingested, edited and stored remotely on network storage, and then a final version is rendered, typically to file, film or videotape.

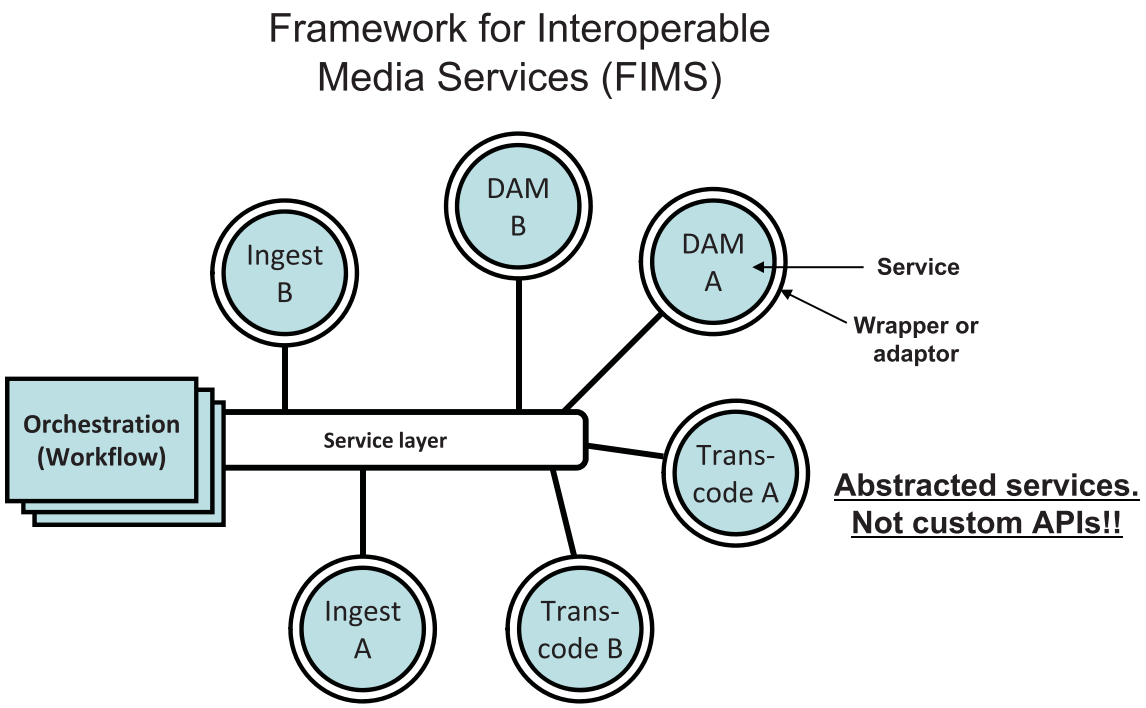

Figure 8
The FIMS framework and common service definitions simplify implementations and extract workflow from DAM systems *(Figure courtesy of Red Bee Media)*

But in *Fig. 9*, a new model is presented. Here you can see that the editing software is loaded on application servers and made available to editing platforms as SaaS. Content is ingested into the editors, and the intermediate work product is stored on local or remote shared storage. Editors in remote locations can also access both the edit software and the shared content. In *Fig. 9*, once the edit project is finalized, a workflow orchestration system accesses media services on the network to transcode the content into other formats, perform audio normalization, and produce an automated QC report.

Significantly, *Fig. 9* also shows an "Authoritative Media Metadata Service". This service is responsible for keeping track of who is the authoritative source for any metadata item associated with content in the system. The system shown in the figure may not seem significant, but in fact, it is revolutionary.

Abbreviations

AAF	Advanced Authoring Format
AMWA	Advanced Media Workflow Association http://www.amwa.tv/
AS	Application Specification
CGI	Computer-Generated Imagery
DAM	Digital Asset Management
DCP	Digital Cinema Package
DPP	Digital Production Partnership (UK) http://www.digitalproductionpartnership.co.uk/
ETC	Entertainment Technology Center http://www.etcenter.org/
FIMS	(AMWA/EBU) Framework for Interoperable Media Services
GoP	Group of Pictures
IMF	Interoperable Mastering Format
IP	Internet Protocol
MXF	Material eXchange Format
QC	Quality Control
SaaS	Software as a Service
SDI	Serial Digital Interface
SMPTE	Society of Motion Picture and Television Engineers (USA) http://www.smpte.org/
URI	Uniform Resource Identifier
VSF	Video Services Forum http://www.videoservicesforum.org/
W3C	World Wide Web Consortium http://www.w3.org/

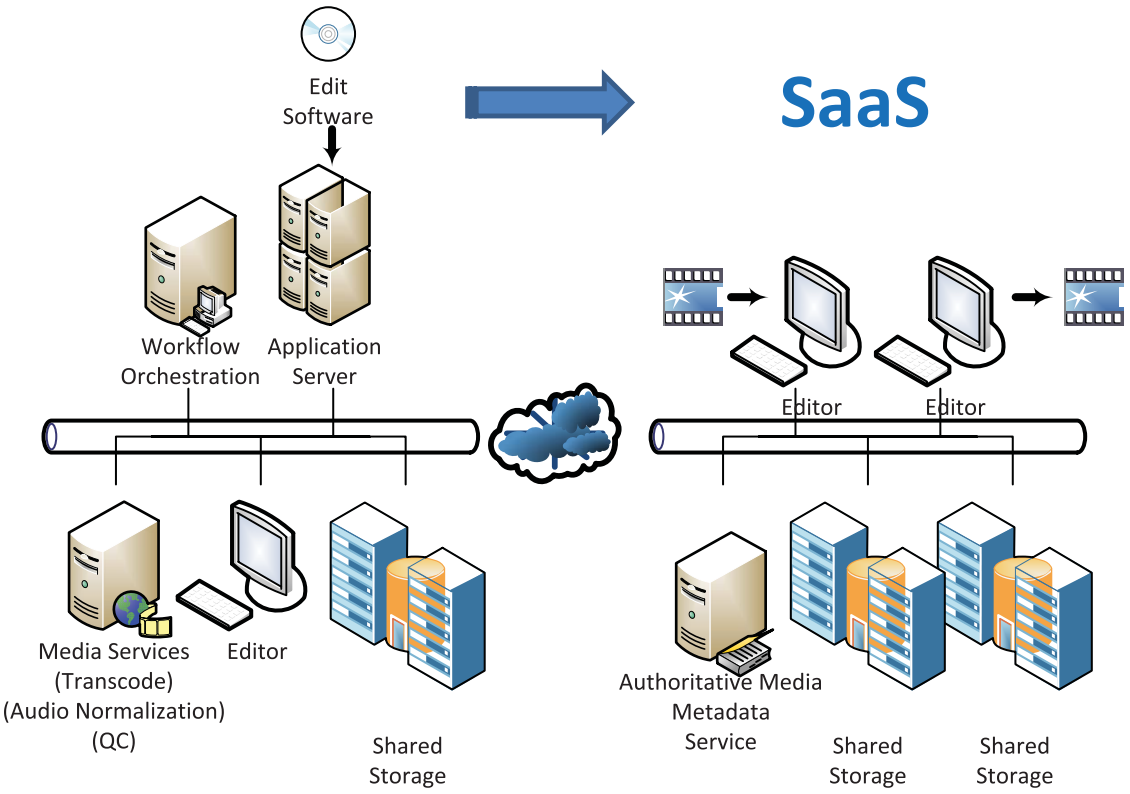

Figure 9
The industry is rapidly moving toward distributed facilities. Users can be anywhere, media can be anywhere and services can be anywhere.

Distributed facilities — the next big thing

As you look at *Fig. 9*, consider the following points:

- Services can be anywhere;
- Users of services can be anywhere;
- Media can be anywhere;
- Applications can be anywhere.

Given these points, one can readily imagine flexible, loosely-coupled, distributed media facilities — facilities that extend far beyond the studio lot or the four walls of a building located in a particular city. In fact, Hollywood studios are already heading in this direction and the trend is accelerating.

There are many arguments which can be offered regarding the practicality of implementing the system shown in *Fig. 9*. Security and network performance are surely near the top of the list. However, many security issues around networked media have already been addressed in the movie production industry and it has been proven that, using a variety of techniques, network performance can be guaranteed. In short, many if not all of the barriers to implementing the system shown in *Fig. 9* can be addressed now, or in the near future.

There is one significant barrier to implementing distributed systems — people. These systems will require major changes in how people think about the media industry, how they approach their jobs and, in fact, this approach requires some special skill-sets in the areas of media, networking and software design. There is no question that education will play a critical role. Also, these facilities will result in major changes, and the media industry would do well to employ some proven change management techniques to help our organizations make the transition to a new way of doing business.

Challenges aside, loosely-coupled distributed facilities based on media services and interoperable media formats provide many of the keys necessary for modern media companies to thrive in these challenging and fast-changing times.

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Mr Gilmer is a Fellow of SMPTE and has been an active participant within SMPTE since 1984. He was previously employed as director of engineering and operations at Turner Broadcasting System Inc. in Atlanta. His staff managed technical and operational aspects of Turner Entertainment's television networks worldwide, including TBS, TNT and Cartoon Network.

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Conclusions

The AAF/MXF data model is gaining acceptance as the dominant representation of metadata in the media industry. MXF is becoming the dominant media wrapper format. Application Specifications are greatly improving MXF interoperability. The concept of the media factory composed of a number of loosely-coupled media services is gaining acceptance in both the Hollywood and television communities. IMF and AS-02 both organize elements into bundles. Bundles may be used by media factories to create finished versions of content for many different target platforms. Interoperable media services enable flexible workflows. The barriers to distributed media facilities are rapidly falling. If the industry properly addresses personnel issues with training and change management, these loosely-coupled distributed facilities can meet the demands being placed on media organizations.

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