METADATA SYSTEMS ARCHITECTURE

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ABSTRACT

During 2002 the remaining documentation of the SMPTE Metadata Registry has been moving into place within SMPTE W25. Although the individual documents are complex and closely interrelated, the full suite of standards provides a comprehensive and simple encyclopaedia of Metadata.

It has long been clear that a Metadata Registry is not an end in itself. Practical applications of the Registry in emerging standards such as the Material Exchange Format (MXF) have been progressing in parallel with the Registry documentation.

SMPTE is now able to examine broader issues in a Metadata Systems Architecture, including: live operation of the Registry, the end to end flow of Metadata through a production system, and the reconciliation of different Metadata schemes (such as EBU P/Meta, MPEG-7 and TV-Anytime) with the SMPTE infrastructure.

This paper begins with a brief review of the structure of the SMPTE Registry, seen from the perspective of a user query of the Registry via the web. The paper then presents a generic system diagram to show metadata flow, which is illustrated with a worked example of multiple stages of the production workflow. In conclusion, the paper describes the ongoing study of mixing SMPTE and non-SMPTE metadata and a potential reconciliation of the corresponding schemas, and presents some preliminary results.

INTRODUCTION – THE SMPTE METADATA REGISTRY

SMPTE has been developing standards for Metadata since before the term was in common use (e.g. SMPTE 12M Timecode). The need for a registry of Metadata was perceived before the inception of the EBU/SMPTE Taskforce, but was put on hold pending the publication of the influential task force report in 1998 (1).

Since then, progress towards delivery of the full SMPTE Registry has been deliberate. In 2002, the last documents have finally reached ballot and will soon catch up with the Metadata Dictionary itself.

Standards in place and forthcoming

Standards which are in place are shown in Figure 1 below. SMPTE 298M-1997 defines Universal Labels, used throughout the SMPTE Metadata hierarchy as a naming and labelling system. SMPTE 336M-2001 defines KLV Encoding, SMPTE 335M-2001 defines the Structure of the Metadata Dictionary (supported by EG37), and RP 210 defines the contents of the SMPTE Dictionary. SMPTE 359M-2001 documents the procedures for administering the Metadata Dictionary (and others) as Dynamic Documents in a Registry, by the SMPTE Registration Authority Inc. at www.smpte-ra.org. (2)

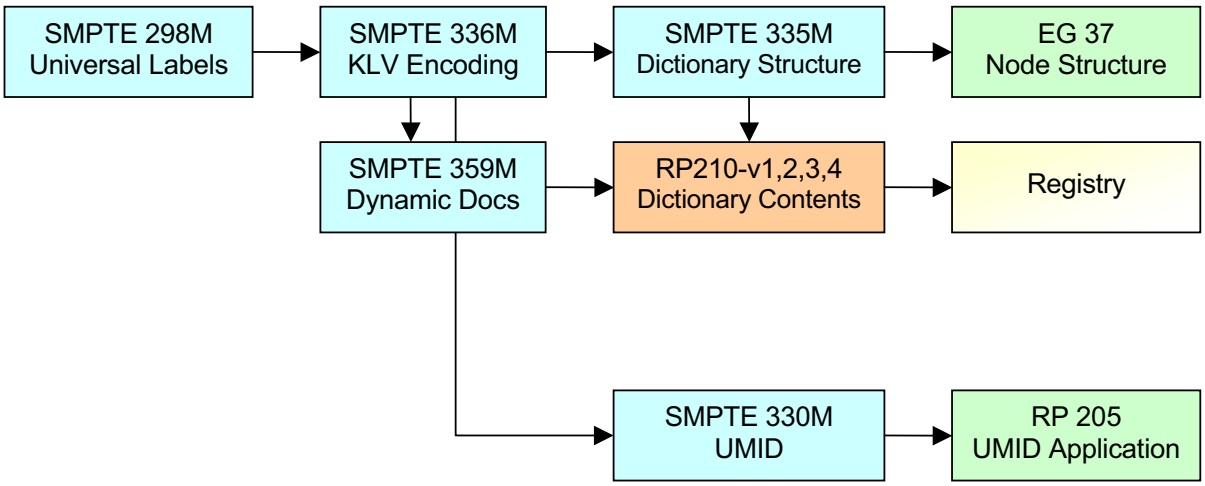

Figure 1 - Approved SMPTE Standards

In addition, a second pair of standards was created to address unique identifiers, also shown in Figure 1. SMPTE 330M-2000 defines Unique Material Identifiers (UMIDs), and RP205 describes recommended practices for application of UMIDs.

To complete the infrastructure work, several additional efforts are underway, illustrated in Figure 2. As well as an XML representation of KLV Encoding, new Registries of Groups, Types, Labels and Enumerated Values are in progress, as well as a revision and extension of the standards and recommended practices on unique identifiers.

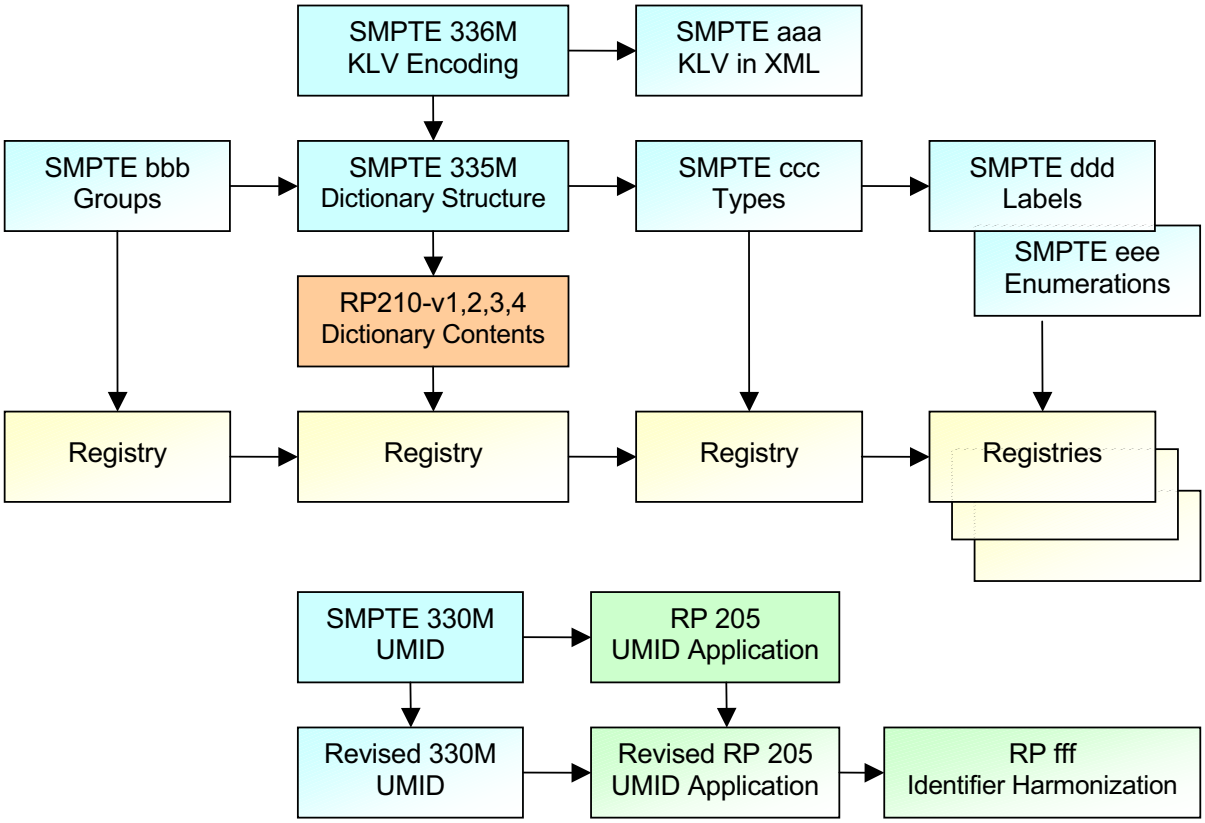

Figure 2 – SMPTE Standards in progress

THE USER'S EXPERIENCE OF THE SMPTE METADATA REGISTRY

At the present time, versions 1 through 4 of the SMPTE Metadata Dictionary have been published in the form of a spreadsheet. An excerpt is shown in Figure 3. Whilst this approach certainly presents all the information in a regular and searchable format, it provides little assistance in penetrating the detail to answer simple questions such as "which metadata item should I use?"

Universal Label	Name	Description	Type
06.0E.2B.34 01.01.01.01 03.02.00.00 00.00.00.00	**Descriptive - Human Assigned**	Descriptors (Human Assigned) relating to analysis of the content	
06.0E.2B.34 01.01.01.01 03.02.01.00 00.00.00.00	**Categorisation**	Analytical categorisation of the content	
06.0E.2B.34 01.01.01.01 03.02.01.01 00.00.00.00	**Content Classification**	Content classification	
06.0E.2B.34 01.01.01.01 03.02.01.01 01.00.00.00	Content Coding System	The system of coding for programme classification eg Escort 2.4	ISO/IEC 646:1991 - ISO 7-Bit Coded Character Set
06.0E.2B.34 01.01.01.01 03.02.01.01 02.00.00.00	Programme Type	Type of programme (e.g., cartoon, film, ...)	ISO/IEC 646:1991 - ISO 7-Bit Coded Character Set
06.0E.2B.34 01.01.01.01 03.02.01.01 03.00.00.00	Genre	Programme genre (e.g., entertainment, current affairs magasine, Italo Western, ...)	ISO/IEC 646:1991 - ISO 7-Bit Coded Character Set

Figure 3 – SMPTE Metadata Dictionary (excerpt)

Browse

The first step in making the Metadata Dictionary more accessible is to convert the dictionary to a more amenable format. The logical choice is XML, using a simple schema which reflects the information fields of SMPTE 335M plus the hierarchical node structure, as shown here:

```
<Node cLevel="2" UL="06.0E.2B.34.01.01.01.01.03.02.00.00.00.00.00.00"
      ElementName="Descriptive - Human Assigned"
      ElementDefinition="Descriptors (Human Assigned) relating to analysis of
                         the content">

<Node cLevel="3" UL="06.0E.2B.34.01.01.01.01.03.02.01.00.00.00.00.00"
      ElementName="Categorisation"
      ElementDefinition="Analytical categorisation of the content">

<Node cLevel="4" UL="06.0E.2B.34.01.01.01.01.03.02.01.01.00.00.00.00"
      ElementName="Content Classification"
      ElementDefinition="Content classification">

<Leaf cLevel="5" UL="06.0E.2B.34.01.01.01.01.03.02.01.01.01.00.00.00"
      ElementName="Content Coding System"
      ElementDefinition="The system of coding for programme classification eg
                         Escort 2.4"
      ElementTypeName="ISO/IEC 646:1991 - ISO 7-Bit Coded Character Set"/>
                                                    </Node></Node></Node>
```

XML permits easy automation for tree-structured browsing. A prototype software tool for automation of Registry operation was created to demonstrate this. Portions of the browser display are shown in Figure 4 and Figure 5

In fact, SMPTE 335M and other registry standards envisage XML as the publication format. However, until the transition to a total XML publication format has been achieved, a spreadsheet format will remain as the reference document for the registry. Therefore, the conversion process has been automated so that spreadsheets may be converted to XML and back as often as necessary. Once the reference format becomes XML, automatic conversion back to a spreadsheet may be used to provide continued support to legacy applications. Interestingly, preparation for the automated conversion was in itself a useful quality assurance check on the contents of the dictionary.

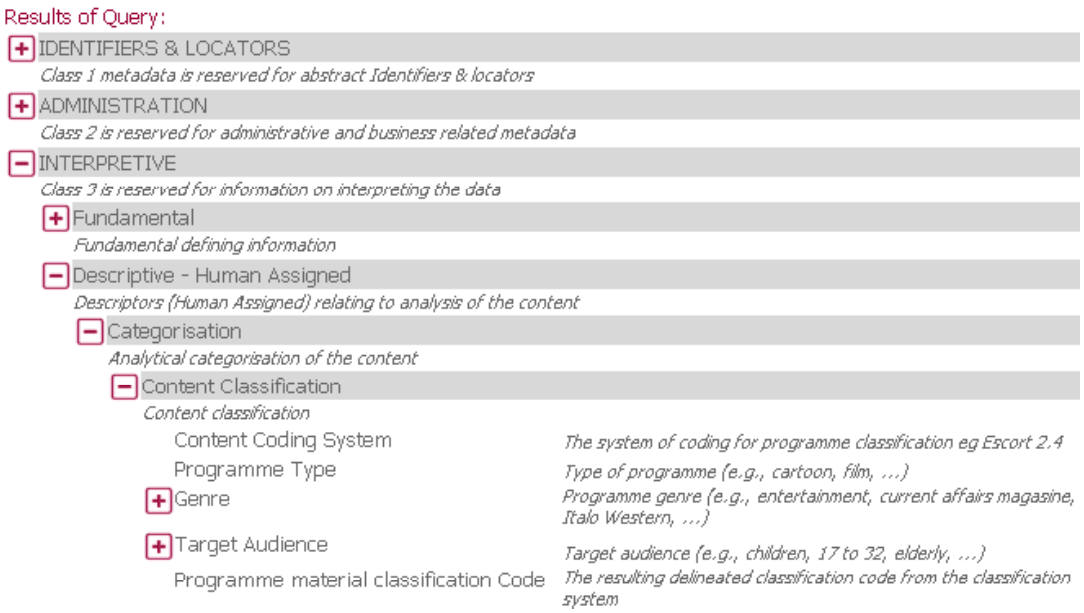

Figure 4 – Browsing of Metadata Dictionary

Further improvement to access may be provided by searches of item names and descriptions. The partial results of a simple search are shown in Figure 5.

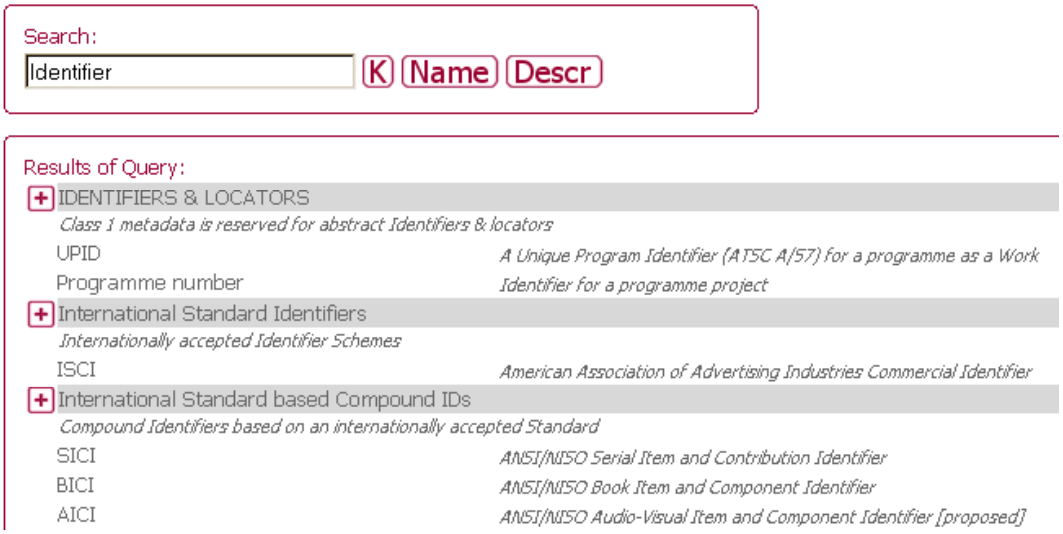

Figure 5 – Results of Search

Full Picture

As can be seen, this query capability is useful for providing quick sets of candidate answers. Unfortunately, very seldom will a query produce a single, 100% correct result. Once candidates have been selected that sound as if they might be right, there are many checks to be carried out:

- Data type
- Semantic information from reference documents
- Hierarchical context
- Where used

All these aspects of the candidates under study can be provided by hyperlinks from the query result page.

Study of these aspects will lead to the candidates being disqualified one by one. If at the end there is a single item left, there is an answer to the original question “which metadata item should I use?” If there are no candidates left, an equally good answer is to register a new item.

Registration Request

Registration, too, can be almost completely automated. The original query already forms the bones of the registration request. To these bones we must add precise description of the new requested item, and then submit the registration request to the Registration Authority for approval.

One of the more important fields in the request is the registration type. SMPTE 359M defines four types of registration:

- Type 1: full due-process review and standardization
- Type 2: technical review
- Type 3: public disclosure of private data
- Type 4: paid reservation of a public name for private data

Going down the list, the amount of peer review decreases and thus the speed of registration increases. However, the direct and indirect costs increase. Fees may be charged for type 4 registrations, which support the future operation of the Registration Authority. More significantly, since there is no guarantee of uniqueness in the lower half of the list, quick and dirty registrations will lead to continuing costs in the long term in translating between non-standard specifications.

GENERIC SYSTEM DIAGRAM

The SMPTE Registry already contains more than 650 approved items, and as the registry becomes more automated, the pace of registration will increase. This section of the paper examines how registered items may pass through systems.

Production and post-production is a multi-stage and iterative workflow. As content passes from idea to finished program, it passes from workstation to workstation along a chain in which the quantity and complexity of both metadata and essence increase and decrease from step to step. This is shown in Figure 6. One reason for retaining metadata later in the chain is to enable the revision, refinishing and repurposing of content.

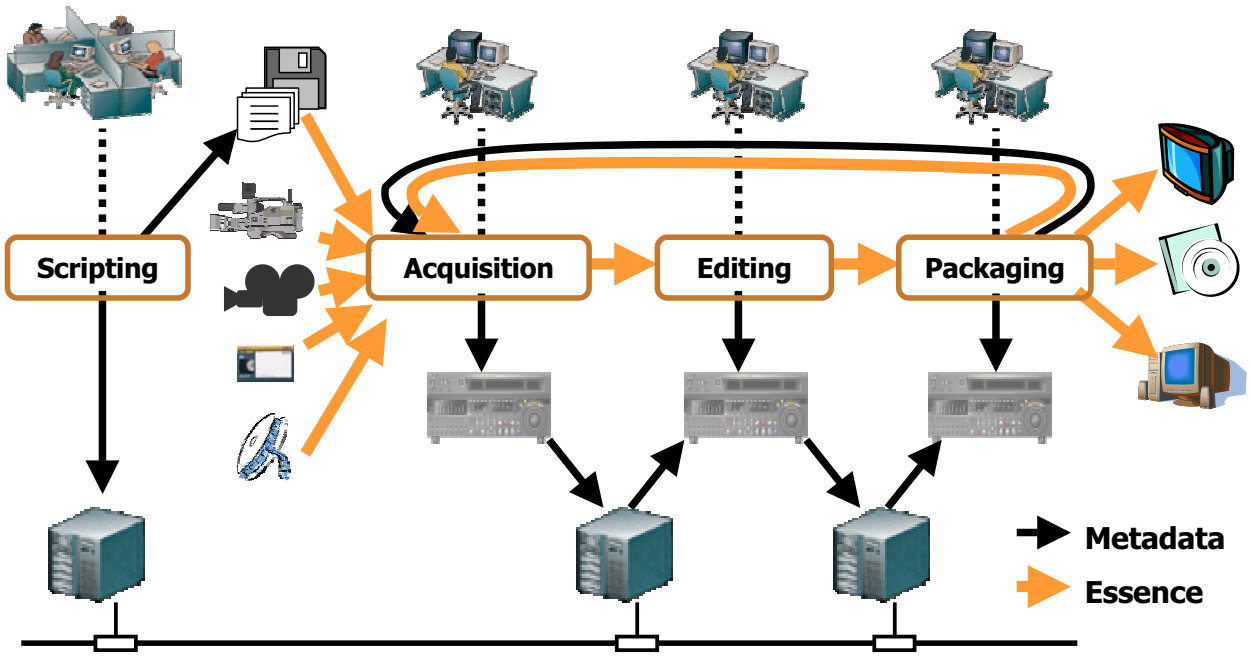

Figure 6 – Content Production Workflow

At the most abstract level, there are three logical system architectures:

- Unified transport of Metadata and Essence
- Parallel flow of Metadata and Essence
- Metadata and Essence retained in a single or federated database

All of these architectures perform the task of providing access from applications to content. No one of these architectures is perfect. All are presently used and will continue to be used at some stage in the content creation chain. All can be seen side-by-side in Figure 6. All must interoperate.

It is the role of standards to set specifications so that systems can be plugged together and the individual units will interoperate. In the past, the specifications were largely for hardware interfaces, for example SDI. As compression came into use and the range of algorithms increased, so it became necessary to write specifications which allow some variation. At first this could be achieved by tabulation of the options within a single document (for example, SMPTE 305M SDTI); a few years ago, it became necessary to provide for an external table of options in the form of a Registry (for example MPEG-2 Systems, ISO 13818-1, for which SMPTE provides the Registration service).

Recently, the first specifications became available which provide for truly generic interconnect, mixing standardized items with registered and user-specified data. The Advanced Authoring Format (AAF) (3) is the prime example of this. Other generic specifications such as the Material Exchange Format (MXF) (4) and the General Exchange Format (GXF) (5) provide for generic multiplexing of an extensible range of image, sound and metadata formats. All these are SMPTE specifications under development or already approved.

APPLICATION EXAMPLE

A simple example of mixing standardized items with registered and user-specified data is described below and follows the same metadata flow as in Figure 6.

Let's suppose we are creating a series of industrial vignettes. For each program, the goal is for the content creator to build a montage of everyday scenes within a given industry, using stock footage where available and appropriate, and supplementing with newly shot material as necessary. An accompanying web page must be created for each program. The more efficiently we can perform the task, the happier the producer will be.

Production Phases

In the Scripting phase, the creator studies the target industry and roughs out a story. This is followed up with research into stock material, from which a storyboard is condensed, along with a shoot plan to acquire the missing material. In the Acquisition phase, original research, storyboard, selected stock footage, and newly acquired material are taken into the Editing phase. In the Packaging phase, the research is culled and sorted according to the finished program, and the associated web page is authored.

Standardized and User-Defined Metadata

Within this simple example, there is much scope for both standardized and for user-defined metadata. SMPTE Metadata is rife within the Editing and Packaging phases. The Content databases in the Acquisition phase might be annotated with MPEG-7 (6). The web pages are constructed in HTML, perhaps using SMPTE DDE or other schemas. In the research phase, there will be broad use of HTML along with industry-specific vocabularies to define, list, arrange and describe the shots.

The industry-specific vocabularies are different for each show. Today this metadata element of the script is carried through the post process using ad-hoc, manpower-intensive techniques; yet the metadata is very amenable to automation: it exists in a consistent relationship to the source material and the finished program, and it must be reduced to a consistent format in the end. The earlier in the production chain that the metadata can be brought into the automation system, the more efficiency can be realized. It would be ideal to build the vocabulary at the start of scripting (in a Word-processor), use this as a database search term (in MPEG-7), as a camera shot log (in MXF), as clip names in the editing bins (in AAF), and as titles in the webpage authoring (in HTML).

STUDY OF SMPTE AND NON-SMPTE METADATA SCHEMAS

This ideal scenario is not too far in the future. The SMPTE Metadata Dictionary and the Registry automation tools shown in prototype above can be used as the open infrastructure in which to define the user metadata. This metadata can already flow from camera through editing to distribution using the file formats defined by SMPTE (and to the end-user, using an extension of MPEG-2 systems). Progress is now also being made in providing standardized translation of SMPTE metadata to and from web-friendly XML, and in reconciling SMPTE metadata to MPEG-7 and other descriptive metadata schemes.

The prototype has already proved useful for reconciling non-SMPTE metadata schemas and for incorporating the output of other SMPTE projects into the Metadata Dictionary.

The prototype was enhanced in two respects: the addition of a second parallel query window to the user interface, and the facility to reduce external metadata schemas to a common form which may be browsed and searched identically to the SMPTE schema.

PRELIMINARY RESULTS

So far this approach has shown an intriguingly high success rate in comparing schemas. Detailed results are still being collated and will be presented at and after the conference (see www.metaglue.com for the latest results).

In summary, the preliminary results show 75% or more overlap between schemes at the surface level of item name and brief description. However, upon deeper study, there are many differences in the precise definition of value types and ranges. These are possible to reconcile; it is much more difficult to reconcile the several differences in relationships between metadata (for example, the relationship between an “author” and a “work”), since in many cases these are the result of a different world-view in the creator of the description schemes

On a theoretical level, it is not certain that the description syntaxes of different schemes can be made compatible at the microscopic level needed for a full merger. As an example, SMPTE Metadata makes use of parallel independent extensibility of instance data, which can be represented in XML documents by the use of namespaces. However, SMPTE Metadata provides no direct support for multiple inheritance of description schemes. When multiple inheritance is used in a non-SMPTE description scheme, the onus will be on the non-SMPTE scheme to map into a single-inheritance representation. This may prove impractical in some cases.

On a practical level, the different user and development communities will continue in their areas of native specialization. For example, all global expertise on Drop Frame Timecode resides within SMPTE, and much expertise on video feature extraction resides in MPEG-7. It is thus reasonable for users to demand and expect carriage of video feature descriptions labelled with Timecode on a common interconnect, with minimal translation.

It is not likely that a full merger of SMPTE Metadata and MPEG-7 (or other schemes such as EBU P/Meta or TV-Anytime) will be achieved, no matter how desirable it is. A lesser goal which could be achieved is a reconciliation in which the regulators of each scheme actively defer to other schemes in areas outside their specialization. This would result in extensive use of the areas of the SMPTE Registry already dedicated to other public organizations, leading to an expanded role for the SMPTE Registration Authority as a United Nations of Metadata.

REFERENCES

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6. International Standards Organization, www.iso.ch, 2002, ISO/IEC 15938-x: Information Technology -- Multimedia content description interface (MPEG-7)

All current SMPTE standard documents can be found on Society of Motion Picture and Television Engineers, www.smpte.org, 2002, CD-ROM of Standards and Recommended Practices for Television.

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