A preliminary crosswalk from METS to IMS content packaging

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Abstract

As educational technology becomes pervasive, demand will grow for library content to be incorporated into courseware. Among the barriers impeding interoperability between libraries and educational tools is the difference in specifications commonly used for the exchange of digital objects and metadata. Among libraries, Metadata Encoding and Transmission Standard (METS) is a new but increasingly popular standard; the IMS content-package (IMS-CP) plays a parallel role in educational technology. This article describes how METS-encoded library content can be converted into digital objects for IMS-compliant systems through an XSLT-based crosswalk. The conceptual models behind METS and IMS-CP are compared, the design and limitations of an XSLT-based translation are described, and the crosswalks are related to other techniques to enhance interoperability.

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Research libraries hold vast and increasing amounts of high-quality digital content. Such content includes not just bibliographic records and born-digital materials, but also digital versions of the library's primary holdings such as archival manuscripts and pictorial collections. Libraries have traditionally provided access to their materials through interfaces created and hosted by the libraries themselves. With the increasing adoption of the tools of educational technology (learning management systems, specialized environments for the teaching of disciplines and presentation of research results) and Web-based collaborative and authoring tools in general, users begin to expect seamless access to library resources in multiple contexts outside library systems.

The library and educational technology communities are only beginning to address jointly the challenges of making library and educational/instructional environments work together ("interoperate") well enough to facilitate seamless access for users[1]. Among the many barriers impeding interoperability between libraries and educational tools is the difference in specifications commonly used for the exchange of digital objects and metadata. Extensible Markup Language (XML) interoperability specifications proposed within the library/digital repository community and within the educational technology domain are geared to the exchange of content within that specific community. By themselves, these standards do not address the need for cross-community transmission of data.

Metadata Encoding and Transmission Standard (METS), which is maintained in the Network Development and MARC Standards Office of the Library of Congress[2] and is being developed as an initiative of the Digital Library Federation[3], uses XML to provide a vocabulary and syntax for applying structural metadata to digital content, and for linking structure and content with pertinent descriptive

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and administrative metadata. It attempts to provide a standard basis for managing digital materials within a digital library, for exchanging materials between digital libraries, and for disseminating the digital content and associated metadata to the end user.

The IMS Content Packaging (IMS-CP) specification, one of several XML-based specifications created under the auspices of the IMS to facilitate interoperability among educational environments, plays a parallel role in the educational technology community:

> The IMS Content Packaging (CP) Information Model describes data structures that are used to provide interoperability of Internet-based content with content creation tools, learning management systems (LMS), and run time environments. The objective of the IMS-CP Information Model is to define a standardized set of structures that can be used to exchange content. These structures provide the basis for standardized data bindings that allow software developers and implementers to create instructional materials that interoperate across authoring tools, LMSs, and run time environments that have been developed independently by various software developers[4].

Of the range of scenarios that need to be accounted for in the full interoperability between library and educational tools, this paper focuses on the case of absorbing METS objects representing library resources into an IMS-CP learning package. The adoption of METS by a significant number of libraries, museums, and archives – a process already well under way – to package their digital content would result in tens of thousands of interesting, high-quality METS documents ready for incorporation into learning tools. Since IMS-CP is emerging as the leading contender for a standard file format for learning content, materials encoded in METS documents will likely find their way into learning environments via translation to IMS-CP. Techniques for such migration are the focus of this article.

Methodology

This article will start by examining a very simple METS document representing a digital version of primary source material – in this case, a manuscript dictation that is part of the Hubert Howe Bancroft Collection held by The Bancroft Library of the University of California, Berkeley. This examination will introduce the main components and features of METS, as these are likely to be applied by research libraries to digital versions of their holdings. Once the article has introduced the key features of METS, it will go on to look at a potential IMS-CP encoding of this same object. The simple METS and IMS-CP documents representing the same digital content will provide a starting-point for a more in-depth discussion of the high level similarities between the two standards, as well as of some conceptual and practical differences. Finally, this article will propose an Extensible Stylesheet Language: Transformation (XSLT) crosswalk intended to serve as a preliminary tool for incorporating library METS objects into learning packages.

Readers should note that METS and IMS-CP are both fairly flexible standards, and this article does not attempt to deal with all possibilities for either a METS encoding or an IMS-CP encoding. The sample METS encoding represents options a research library is likely to use when representing digital versions of their holdings in METS. There is, however, no standard library METS encoding or profile, at least at this point, and, even within this relatively small community, practices are likely to vary fairly widely. Nor is there a standard encoding for learning packages, although various groups are exploring more narrowly-defined profiles and implementations of IMS-CP. When and if profiles emerge that narrow the range of METS and IMS-CP options and practices for certain applications, it should be possible to write profile-specific transformations between METS and IMS-CP objects that have fewer ambiguities. In the meantime, this article does not attempt to suggest a definitive encoding for library METS objects nor for IMS-CP objects. At best, it can suggest a preliminary, provisional and contingent means for absorbing library METS objects into IMS-CP packages.

This article assumes that METS and IMS-CP are not competing standards, and its purpose is not to appraise their relative merits. These are standards that attempt to meet the needs of different communities, and the main purpose here is to surface the concepts and to begin to establish a vocabulary that can facilitate communication and collaboration between the

learning and library communities, which after all share many common goals.

Simple encoding compared

The simple METS and IMS-CP documents presented below are much simpler than would be encountered in the real world, but will help to clarify high-level similarities between METS and IMS-CP. In particular, the descriptive and administrative metadata represented in the documents, which are encoded using the Metadata Object Description Schema (MODS)[5] and Metadata for Images in XML (MIX)[6] standards respectively, simply serve as placeholders for what would typically be much richer encodings. Also note that the samples omit some XML management data for the sake of clarity, and that consequently the documents will not validate as shown. (Full versions of the simple METS document and its simple IMS-CP version are available online[7]. A Web presentation of the sample METS document is also available[8].)

Simple METS document

Below are the top level elements that can comprise a METS document (see Figure 1):

- [metsHdr (header)]
- dmdSec (descriptive metadata section)
- amdSec (administrative metadata section)
- fileSec (file section)
- structMap (structural map)
- [structLink (structural links section)]
- [behaviorSec (behavior section)]

Note that the sample METS document does not demonstrate the bracketed sections above (header, structural links section or behavior section). These have important functions for some applications but are not among the core sections of METS.

Of the core sections, the structural map (structMap) is the most important, and is in fact the only required element of a METS document. This map analyzes the structure of the digital content represented into a hierarchically arranged sequence of divisions (div elements). In the case of the simple example in Figure 1, the structural map simply analyzes the dictation into a sequence of two physical pages. The structural map goes on to link these pages to the files in the file section that manifest their content. Since only one manifestation of each page is available, each page division points (by means of a file pointer or fptr element) to single file. The file section, then, mainly provides an inventory of the files that comprise the content of the digital object represented. Each file element points to the external content file it represents via a URI.

The optional descriptive metadata (dmdSec) and administrative metadata (amdSec) sections of a METS document record the descriptive and administrative metadata pertinent to the digital content. METS does not itself define a descriptive or administrative metadata element set, and the example records these metadata using elements defined in external standards maintained by the Library of Congress: MODS and MIX. The root division of the structural map points to the single descriptive metadata section present in the METS document, since these descriptive metadata pertain to all the content represented by the structural map. Each file in the file section points to the section of technical administrative metadata that pertains to it.

Simple IMS-CP version

The simple IMS-CP version of the METS document could be a product of a simple transformation, as specified by an XSLT stylesheet (see Figure 2). This article will discuss such a possible transformation stylesheet below. Here the focus is on the high level details of the content package itself.

Below are the top level elements which can comprise an IMS-CP document and are demonstrated by the transformed METS document:

manifest
* organizations o organization
* resources o resource

The IMS-CP organizations element can contain different possible organizations of the content, one of which must be the default and each of which is represented by an organization element. The IMS-CP organization element corresponds to the METS structural map (which is also repeatable). Like the METS structural map, the IMS-CP organization element analyzes the structure of the learning package into a hierarchically-arranged sequence

Figure 1 Simple METS encoding

```
<?xml version="1.0" encoding="UTF-8"?>
<mets:mets LABEL="Dictation from Amelia Hartman Saunders">
    <mets:dmdSec ID="DMD1">
        <mets:mdWrap MDTYPE="MODS">
            <mets:xmlData>
                <mods:mods>
                    <mods:titleInfo>
                        <mods:title>Dictation from Amelia Hartman Saunders : ms., Sacra
                        mento : 1887</mods:title>
                    </mods:titleInfo>
                    <mods:abstract>From miscellaneous California dictations
                    prepared for H.H. Bancroft</mods:abstract>
                </mods:mods>
            </mets:xmlData>
        </mets:mdWrap>
    </mets:dmdSec>
    <mets:amdSec>
        <mets:techMD ID="ADM1">
            <mets:mdWrap MDTYPE="NISOIMG">
                <mets:xmlData>
                    <mix:mix>
                        <mix:BasicImageParameters>
                            <mix:Format>
                                <mix:MIMEType>image/jpeg</mix:MIMEType>
                            </mix:Format>
                        </mix:BasicImageParameters>
                    </mix:mix>
                </mets:xmlData>
            </mets:mdWrap>
        </mets:techMD>
    </mets:amdSec>
    <mets:fileSec>
        <mets:fileGrp USE="REFERENCE">
            <mets:file ID="FID1"  ADMID="ADM1">
                <mets:FLocat xlink:href="http://sunsite.berkeley.edu/moa2/images/bkm00
                002773a_b.jpg" LOCTYPE="URL"/>
            </mets:file>
            <mets:file ID="FID2"  ADMID="ADM1">
                <mets:FLocat xlink:href="http://sunsite.berkeley.edu/moa2/images/bkm00
                002774a_b.jpg" LOCTYPE="URL"/>
            </mets:file>
        </mets:fileGrp>
    </mets:fileSec>
    <mets:structMap TYPE="physical">
    <mets:div LABEL="Dictation from Amelia Hartman Saunders"
    DMDID="DMD1">
        <mets:div TYPE="page" LABEL="Page [1]">
            <mets:fptr FILEID="FID1"/>
        </mets:div>
        <mets:div  TYPE="page" LABEL="Page [2]">
            <mets:fptr FILEID="FID2"/>
        </mets:div>
    </mets:div>
  </mets:structMap>
</mets:mets>
```

of divisions (items) – here representing the two pages of the manuscript dictation. Each of these items points to the resource in the resources section that manifests the content of the page it represents. (It does this by means of an identifierref attribute.) The resources section, then, provides an inventory of the resources that together comprise the content of the learning package and corresponds to the METS file section.

Figure 2 Simple IMS-CP version

```
<?xml version="1.0" encoding="utf-8"?>
<manifest>
    <organizations default="structMap">
        <organization identifier="structMap">
            <item identifier="N104">
                <title>Dictation from Amelia Hartman Saunders</title>
                <item identifier="N108" identifierref="FID1">
                    <title> Page [1]</title>
                </item>
                <item identifier="N115" identifierref="FID2">
                    <title> Page [2]</title>
                </item>
                <metadata>
                    <schema>MODS</schema>
                    <mods:mods>
                        <mods:titleInfo>
                            <mods:title>Dictation from Amelia Hartman Saunders : ms., S
                            acramento : 1887</mods:title>
                        </mods:titleInfo>
                        <mods:abstract>From miscellaneous California dictations
                        prepared for H.H. Bancroft</mods:abstract>
                    </mods:mods>
                </metadata>
            </item>
        </organization>
    </organizations>
    <resources>
        <resource identifier="FID1" type="webcontent" href="http://sunsite.berkeley.edu
        /moa2/images/bkm00002773a_b.jpg">
            <metadata>
                <schema>MIX</schema>
                <mix:mix>
                    <mix:BasicImageParameters>
                        <mix:Format>
                            <mix:MIMEType>image/jpeg</mix:MIMEType>
                        </mix:Format>
                    </mix:BasicImageParameters>
                </mix:mix>
            </metadata>
        </resource>
        <resource identifier="FID2" type="webcontent" href="http://sunsite.berkeley.edu
        /moa2/images/bkm00002774a_b.jpg">
            <metadata>
                <schema>MIX</schema>
                <mix:mix>
                    <mix:BasicImageParameters>
                        <mix:Format>
                            <mix:MIMEType>image/jpeg</mix:MIMEType>
                        </mix:Format>
                    </mix:BasicImageParameters>
                </mix:mix>
            </metadata>
        </resource>
    </resources>
</manifest>
```

Like a METS document, a learning package can also present pertinent descriptive and administrative metadata. IMS-CP, however, does not segregate such metadata from the structure and content. In the sample document, therefore, the descriptive metadata pertaining to the manuscript appear directly within the organization element that analyzes its structure, and the technical metadata about each resource appear directly within the resource element to

which the metadata pertain. Like METS, IMS-CP does not itself specify descriptive and administrative metadata elements, and an IMS-CP document must use elements defined in external standards to encode such metadata. The sample IMS-CP document uses the same standards as the METS sample: MODS and MIX. In the real world, as this article discusses later, an IMS-CP document would be more likely to use the IMS Metadata (IMS-MD) specification[1] or the very closely-related IEEE Learning Objects Metadata (LOM) standard[9].

High level comparison

As the simple METS and IMS-CP examples given in Figures 1 and 2 demonstrate, there is a great similarity between the two standards at the highest level. Both provide for:

- inventorying the resources or files that make up the content of a digital object;
- specifying how the resources all fit together into a coherent, hierarchically structured whole; and
- expressing descriptive and administrative metadata pertaining to the content.

Both METS and IMS-CP allow the content files comprising a digital object to be assembled in more than one way, thereby providing the user with different possible approaches to and experiences of the same content. Neither defines nor prescribes a particular vocabulary for describing the content of the digital object, nor for expressing associated administrative metadata such as information about how the content files were produced, or what rights restrictions pertain to their use. Both allow external standards to be used for these purposes.

Differences in provisions for content

Despite the high-level similarity between the two standards, certain conceptual and practical differences are likely to distinguish documents implementing the two standards. These differences can pose challenges for absorbing METS objects representing library resources into an IMS-CP learning package.

As demonstrated by the simple example, a METS document can enumerate the files comprising the digital version of library material, and express the structural relationship between these files. The METS document could also go on to specify how these content files should be presented to the end user – the library patron – by identifying an appropriate presentation program and specifying how this presentation program should be invoked. If the METS document did specify a presentation, however, this presentation would be clearly separated from the digital content. (It would be specified in the behavior section not covered in the simple example.) As applied by many libraries, METS documents representing digital versions of primary holdings will probably not address presentation at all; rather, these METS documents will simply point to the raw digital content, and provide structural clues on which any number of presentations of this content might be based. While presentation of the content to library patrons is, of course, very important, different uses, audiences, times and available technologies are likely to require different presentations. A library is likely to be less concerned with using METS to pin down a particular presentation of digital library materials than with providing for long-term preservation of the content itself, and ensuring its ability to communicate the structure and content of these materials to other times, places and institutions.

While a Web-based presentation of the content represented by a library METS document is very likely, the METS document may do no more than provide the structural clues on which such a presentation could be based. In the library at the University of California at Berkeley, for example, a Java servlet-based program called GenView disseminates the content of library METS objects to end users; but the METS documents themselves make no reference to GenView, and they make no attempt to make their content files "GenView-ready" (by wrapping the content in html, for example). And GenView is just one of many potential programs that might disseminate the content of a UC Berkeley Library METS document.

Like METS, the IMS-CP standard does not dictate a particular presentation of content; nonetheless, it is common for IMS-CP documents to organize their content files into "Webcontent" resources. Such resources presuppose browser presentation and in

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addition to raw content files (such as image, audio and/or video files) such resources are likely to include an HTML file that controls the presentation of the content files in the user's browser. And the HTML file is likely to invoke auxiliary program files, with appropriate parameters, to assist with the presentation of the content. When an IMS-CP document organizes "Webcontent", it in fact does not distinguish strongly between presentation and content, and it considers the HTML file that manages the presentation as an integral part of the content.

Absorbing a METS document into a learning object representing "Webcontent" and presupposing browser presentation may involve some challenges. Where the content files specified in the METS document are already Web browser-compatible (as would be the case with jpeg and gif images), there is no problem. These can simply become "Webcontent" resources in the learning package. Where the content files are audio or video files, which the browser cannot present natively, however, the METS content must somehow be made browser-ready before it can be absorbed into the learning package. If the METS document analyzes its content into a structure that references just parts of files (a timed segment of an audio file, for example) or if the METS document makes available multiple versions of the same content (images at different resolutions, for example), then accommodating the METS content to IMS-CP "Webcontent" becomes more complex still.

Differences in provisions for associated metadata

Neither METS nor IMS-CP itself explicitly prescribes a standard vocabulary for expressing descriptive and administrative metadata. As noted above, both allow these metadata to be expressed using external standards. The communities that use METS and IMS-CP are likely to favor the use of certain standards for certain purposes. The learning community, for example, strongly favors the use of IMS-MD (or LOM) in IMS-CP documents. The favored auxiliary metadata schemata in METS are not always so clear-cut. Libraries using METS are likely to favor MODS, Dublin Core (DC) or even MARCXML for describing content; museum communities will probably favor Visual Resources Association (VRA) (when an XML version of this standard becomes available). Most METS users will probably favor MIX, based on the NISO data dictionary (Z39.87), for capturing technical metadata about images. The choice for other administrative metadata categories, such as rights, is not so clear.

When absorbing a METS object into an IMS-CP package, parsing out, say, MODS and MIX metadata into IMS-MD categories and elements would not be straightforward. For one thing, METS and IMS-MD tend to categorize descriptive and administrative metadata in ways that are not precisely aligned. Furthermore, IMS-MD tends to be descriptive-metadata-poor from a library cataloging practice standpoint, and technical-metadata-poor from a preservation standpoint. On the other hand, descriptive and administrative metadata in a library METS object are likely to lack many metadata elements pertinent to courseware and learning environments.

While a translation from MODS and MIX to IMS-MD is likely to incur fairly substantial losses, it is not clear that such losses would be especially significant from a practical standpoint insofar as the transformed METS object would not be a replacement for its original; rather, it would simply be a surrogate "rearranged" to perform in another – learning – environment. The losses would only be important if they affected the performance of the transformed METS object within this environment. The inability of the library METS object to provide certain metadata pertinent to learning environments might be the more serious deficiency. Given sufficient resources and expertise, IMS-MD metadata could of course be included in library METS objects in anticipation of their being absorbed into electronic course materials.

Both IMS-CP and IMS-MD accommodate descriptive and administrative metadata elements from other standards, so any elements appearing in a source METS document for which IMS-MD provided no analogue could still be represented in an IMS-CP object, even within the context of IMS-MD metadata. Still, the extent to which advantage can be taken of such open policies is probably limited. Such

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policies can effectively dismantle the very standard that provides for them, and make it more difficult to manage the objects implementing the standards in their target environments.

A model XSLT-based crosswalk from METS to IMS-CP

Figure 3 presents a crosswalk from METS to IMS-CP written in XSLT[10]. A traditional crosswalk is "a table that maps the relationships and equivalences between two or more metadata formats"[11]. By expressing the crosswalk mapping as XSLT, one can use a server or client-side XSLT engine to transform a METS document to a corresponding IMS-CP object.

The crosswalk presented in Figure 3 is a preliminary one aimed at transforming relatively simple METS documents such as that listed in Figure 1. That is, the XSLT captures the high level correspondences between METS and IMS-CP, mapping the respective XML elements that comprise the inventory of files and their hierarchical relationships.

If one uses the XSLT engine hosted by the World Wide Web Consortium (W3C) to transform the simple METS document (Figure 1), one will notice that the resultant IMS-CP document[12] is not the same IMS-CP as in Figure 2. The crosswalk presented here has some key limitations, most important of which is that there is no attempt to transform any of the metadata of the METS document. On the other hand, the IMS-CP document presented in Figure 2 was written to include descriptive and administrative metadata elements so as to illustrate the placement of these metadata elements in the IMS-CP structure.

Again, the XSLT is presented in the article mostly as a proof-of-concept that XSLT is a convenient, expressive and powerful way to formalize a crosswalk from METS to IMS-CP.

Future work

Refining crosswalks through analysis of specifications

The crosswalk between METS and IMS-CP is clearly at the early stages of development. The close comparison between METS and IMS-CP presented in this article suggests many needed refinements. Including descriptive and administrative metadata translations in the crosswalk would be one such refinement. A basic approach would be to directly copy the metadata from a METS document into the IMS-CP package, given that IMS-CP permits the incorporation of arbitrary XML-based metadata[13]. IMS-MD allows for extensions, resulting in yet another place to incorporate arbitrary XML-based metadata[14]. On the other hand, if one wants to express metadata in terms of core IMS-MD, the preferred metadata schema for IMS-CP, one is faced with the challenge of translating the arbitrary metadata schema permissible in METS to IMS-MD. A crosswalk-writer might be saved from such a grim scenario, should he choose to limit himself to popular metadata specifications to be found in METS. Which metadata specifications are popular remain to be determined by the patterns of adoption of METS, which is in the early stages.

Crosswalks from IMS-CP to METS can be written to enable the migration of digital content in the opposite direction, for example, the archiving (preservation) of learning materials by a library or the hosting of learning materials through library-hosted digital repositories. The detailed comparison between the METS and IMS-CP of this article should help jump-start such an effort. Tackling an IMS-CP to METS crosswalk, however, does bring up questions that might require input beyond analyzing the specifications *per se*. Does it make sense to attempt to translate the elements of an IMS-CP document into METS or would it be suitable just to wrap the IMS-CP document in a METS document, and possibly expose some of the descriptive metadata at the top level of the METS wrapper? Is it possible to round-trip documents between the two specifications? If not, is modifying the specifications to allow round-tripping a worthwhile goal for which to aim?

Refinements that await practical experience in the community

Effective crosswalks able to translate real-world METS documents into viable IMS-CP objects need to account for not only the formal structures of METS and IMS-CP, but also how

Figure 3 METS to IMS-CP crosswalk

```
<?xml version="1.0" encoding="UTF-8"?>
<!DOCTYPE stylesheet [
        <!ENTITY nbsp "<xsl:text disable-output-escaping=&#34;yes&#34;
   xmlns:xsl= &#34;http://www.w3.org/1999/XSL/Transform &#34;
   >&amp;nbsp;</xsl:text>">
]>
<xsl:stylesheet version="1.0"  xmlns="http://www.imsglobal.org/xsd/imscp_v1p1"
xmlns:xsl="http://www.w3.org/1999/XSL/Transform"
xmlns:fo="http://www.w3.org/1999/XSL/Format"
xmlns:imscp="http://www.imsglobal.org/xsd/imscp_v1p1"
xmlns:imsmd="http://www.imsglobal.org/xsd/imsmd_v1p2"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xmlns:xlink="http://www.w3.org/TR/xlink"  xmlns:METS="http://www.loc.gov/METS/"
>

        <!--output-->
        <xsl:output encoding="UTF-8" method="xml" media-type="text/xml"/>

        <!--attributes for namespaces of various IMS CP and MD and METS-->
        <xsl:attribute-set name="manifestNS">
                <xsl:attribute
name="xsi:schemaLocation">http://www.imsglobal.org/xsd/imscp_v1p1
http://www.imsglobal.org/xsd/imscp_v1p1p3.xsd
http://www.imsglobal.org/xsd/imsmd_v1p2
http://www.imsglobal.org/xsd/imsmd_v1p2p2.xsd http://www.loc.gov/METS/
http://www.loc.gov/standards/mets/mets.xsd</xsl:attribute>
        </xsl:attribute-set>

        <!-- METS:mets -->
        <xsl:template match="METS:mets">
                <xsl:element name="manifest"
namespace="http://www.imsglobal.org/xsd/imscp_v1p1"  use-attribute-
sets="manifestNS">
                        <xsl:attribute name="identifier">MANIFEST01</xsl:attribute>
                        <metadata />  <!-- blank for now -->

                        <!--organizations (can have multiple organizations) -->
                        <!-- organization is a recursive structure and hence can hold the
recursive FileGrp mapping as well as StructMap -->
                                <organizations>
                                        <xsl:attribute
name="default">structMap</xsl:attribute>  <!--set StructMap mapping as the default -->
                                        <xsl:apply-templates select="METS:structMap"
mode="MapToOrganization" />
                                        <!-- Would be also good to map the fileSec to a
secondary Organization (instead of just flattening it out into the Resources -->
                                        <xsl:apply-templates select="METS:fileSec"
mode="MapToOrganization" />
                                </organizations>

                        <!--resources -->
                        <resources>
                                <xsl:apply-templates select="METS:fileSec"
mode="MapToResources" />
                        </resources>
                </xsl:element>
        </xsl:template>

        <!--Generate Organization (from structMap) -->
        <xsl:template match="METS:structMap" mode="MapToOrganization">
                <organization>
                        <xsl:attribute name="identifier">structMap</xsl:attribute>
                        <!-- could put title and metadata here (but I don't know of a
```

(*continued*)

Figure 3

```
mapping for it -->
                        <xsl:apply-templates select="METS:div" mode="MapToItem"/>
                    </organization>
        </xsl:template>

        <!-- METS:div to IMS:item -->
        <xsl:template match="METS:div" mode="MapToItem">
                <item>
                        <xsl:attribute name="identifier"><xsl:value-of select="generate-
id(.)" /></xsl:attribute>
                        <title><xsl:value-of select="@LABEL" /></title>
                        <xsl:apply-templates select="METS:fptr" mode="MapToItem"/>
                        <!--recursive application of div -->
                        <xsl:apply-templates select="METS:div" mode="MapToItem"/>
                </item>
        </xsl:template>

        <!--METS:fptr to IMS:item -->
        <xsl:template match="METS:fptr" mode="MapToItem">
                <item>
                        <xsl:attribute name="identifier"><xsl:value-of select="generate-
id(.)" /></xsl:attribute>
                        <xsl:attribute name="identifierref"><xsl:value-of
select="@FILEID" /></xsl:attribute>
                        <title><xsl:value-of select="../@LABEL"/> (<xsl:value-of
select="normalize-space(id(@FILEID)/@MIMETYPE)" />)</title>  <!--subjective
mapping -->
                </item>
        </xsl:template>

        <!-- Generate Resources -->
        <!--FileGrp is a recursive structure whereas Resource cannot contain another
Resource.
        Right now, I will just map out the files (in METS, we can have mptr, so this type
of solution is not sufficient for METS
        -->

        <xsl:template match="METS:fileSec" mode="MapToResources" >
                <xsl:apply-templates select="METS:fileGrp" mode="MapToResource" />
        </xsl:template>

        <xsl:template match="METS:fileGrp" mode="MapToResource">
                <xsl:apply-templates select=".//METS:file" mode="MapToResource" />
        </xsl:template>

        <xsl:template match="METS:file" mode="MapToResource">
                <resource>
                        <xsl:attribute name="identifier"><xsl:value-of
select="@ID"/></xsl:attribute>
                        <xsl:attribute name="type">webcontent</xsl:attribute>  <!--
webcontent is the only legal type right now -->
                        <xsl:attribute name="href"><xsl:value-of select="normalize-
space(METS:FLocat/@xlink:href)" /></xsl:attribute>
                        <!--metadata (blank for now)-->
                        <metadata />
                        <!--for resources with only one file, one can put the file ref right
into the href attrib of resource or create a file child element -->
                        <!--I thought that file can be used for remote files  but the LRN
viewer did not let me -->
                        <!--so  I need to map it to href of resource -->
                </resource>
        </xsl:template>

</xsl:stylesheet>
```

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METS and IMS-CP are actually used in practice. Although documentation about the two schemata is readily available, the authors have had access to a limited range of real-world METS and IMS-CP documents. It is too early to expect to find a comprehensive library of representative documents, since both the adoption cycles for METS and IMS-CP are still in the early stages. Consequently, the full range of scenarios in which METS documents can be sensibly incorporated into IMS-CP objects remains unexplored. Both specifications are broad and flexible, able to encompass a wide range of use. Indeed, both communities have applied the notion of application profiles to formalize specific applications of the specifications[15]. The METS community is currently working on a standard to govern METS profiles, and intends to establish a registry of profiles[16]. The Centre for Educational Technology Interoperability Standards (CETIS) has been sponsoring "codebashes" in which representative IMS-CP packages are being accumulated[17]. Canadian Core Learning Resource Metadata Application Profile (CanCore)[18] and Sharable Content Object Reference Model (SCORM)[19] are application profiles of IEEE LOM and the IMS-CP/IMS-MD specifications, respectively.

The development of profiles for METS and IMS-CP will make the task of writing crosswalks more focused and tractable. A crosswalk that translates between two given profiles of METS and IMS-CP does not need to handle the full range of possibilities that arbitrary METS and IMS-CP documents can encompass. Since no profiles for METS yet formally exist, the crosswalk presented in this article is based not on a profile of METS, but on a somewhat arbitrary narrowing of METS that highlights core features of the specification. As profiles develop, this crosswalk can be elaborated to handle them. Selecting profiles between which to translate will be greatly aided by discussion with members from the library and educational technology communities about promising profiles and the nuances of how various concepts in communities can or cannot be translated.

With or without formal profiles, viewers, editors, or other tools that actually work with the XML specifications make writing crosswalks much easier than having the specifications alone. Complex specifications such as METS and IMS-CP are abstractions, full of ambiguities. Working tools embody a set of practices around a specification, even if such practices are not formally documented. Being able to validate documents against the METS and IMS-CP schema is an important first step; nonetheless, not being able to play a valid document in a viewer is roughly akin to writing grammatically correct English sentences without knowing whether they represent anything a native speaker would actually say. The GenView METS/Making of America II (MOA2) viewer implemented by the UC Berkeley Library Systems Office, which can be fed any Web-based METS document, was a tremendous aid to the authors in understanding and communicating the nature of the METS specification in theory and practice. Although there are open source tools for the reading and editing of IMS-CP documents (e.g. Reload[20]), the authors do not know of any publicly-available Web-based viewer for IMS-CP. This deficiency hinders IMS-CP adoption and development. With a publicly Web-based IMS-CP viewer, one could quickly learn about IMS-CP through creating a trial IMS-CP document and feeding it to the viewer. Writers of crosswalks could both present the XSLT crosswalk and send the product of the translation to such a viewer, thus demonstrating the crosswalk in action.

A note of caution is in order. Although working applications are invaluable, one must not read too much into how a specification is interpreted by any particular application, since that tool might be demonstrating an incomplete or incorrect interpretation of the specifications, or a particular interpretation when many others are legitimate.

Crosswalks in the context of continued dialogue between the library and educational technology communities

Ideally, this article will provide some encouragement and guidance to the developers of interoperability specifications in the library and educational technology communities to harmonize related specifications where possible, thus reducing the need for crosswalks in the first place. One primary goal of this article is to develop awareness in the two communities of

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the existence and development of METS and IMS-CP – activities that have gone on largely in parallel – and to offer tentative bridges between the two specifications through the mechanism of a crosswalk.

One possible solution to the problem of METS and IMS-CP interoperability would be to abandon one specification in favor of the other, or to fuse the two into some greater specification that subsumes both. Pursuing such a strategy, however, is probably at once unrealistic and inappropriate. It is unrealistic because there is already momentum behind the two specifications in their respective communities. It is inappropriate because each specification reflects the needs of its own community. It is not obvious from comparing the two specifications that one can subsume the other. Although the library community and the educational technology communities might be expected to have major similarities, there is little reason to believe that all their needs can be met in one specification. There is still the possibility that METS and IMS-CP could be unified into a super-standard that fully encompassed the two specifications, along with a super-metadata specification that could subsume MODS, MIX, LOM, and all other significant metadata specifications. Even if such a synthesis were possible, would the complexity of such a super-specification be so great that it would never be adopted? (Norm Friesen provides a very helpful discussion of the issues raised here[21].)

Semantic interoperability in the large: moving beyond only METS and IMS-CP

It is not hard to imagine that library users would like to draw on multiple sources of digital content in seamless, integrated ways regardless of underlying protocols and data/metadata-encoding schemes. Creating the full spectrum of interoperability required for such functionality remains an extremely challenging and multifaceted research problem. Among the various aspects of interoperability is the problem of semantic interoperability, "integrating resources that were developed using different vocabularies and different perspectives on the data" (Heflin and Hendler, 2000).

Writing crosswalks between METS and IMS-CP is a pragmatic approach to enhancing semantic interoperability among libraries and educational technology. Although this article has focused solely on interoperability between the two XML specifications of METS and IMS-CP, the authors are mindful that there are many other specifications used to encode content that many users will want translated into IMS-CP or METS. By focusing on a small number of XML-based interoperability specifications that are of importance in the various domains, this article has been able to propose direct crosswalks between the specifications, and thereby avoid the need for an abstract scheme that encompasses a myriad XML specifications.

Such an approach, obviously, does not scale as the number of XML specifications increases. It is important, therefore, to also consider other more generically focused interoperability efforts in the library and educational technology communities. Godby and her group at OCLC have been working on a metadata schema translation service to apply crosswalks (such as the one produced in this article) to input documents via Web services (Godby *et al.*, 2003). Semantic interoperability of metadata and information in unlike environments (SIMILE) is a recently funded, large-scale collaboration among the MIT Library (DSpace), the MIT Computer Science department, Hewlett Packard, and the W3C to leverage the connection among libraries, the semantic Web, and personal information management[22]. A practical question for writers of crosswalks is whether the crosswalks can be written in such a way as to make easier the automated extraction of knowledge implicit in the XSLT for projects such as SIMILE. As users become interested in extracting sections, rather than the whole, of METS and other XML documents, the question of how crosswalks can be modified to enable the disaggregating and recombining of content from multiple documents will arise. Although this issue has not yet hit the library and educational technology communities, one can get a glimpse into how it may play out by studying the debates around Rich Site Summary or RDF Site Summary (RSS) and related formats among Weblogging

technologists. RSS is a family of XML formats used to syndicate content ranging from news items, Weblog entries, and "pretty much anything that can be broken down into discrete items"[23]. RSS has also been a quickly evolving testbed (and lightning-rod) over a number of questions: Is it better to extend RSS via the addition of core elements or by modules? How important is the readability of the format to adoption and creative use of the format[24]? Are the benefits of casting RSS (or its successor) in the framework of Resource Description Framework (RDF), part of the semantic Web stack) worth the increased abstraction[25]? Are the demands of "episodic Web sites" such as Weblogs better served by the creation of a new specification or by working with RSS[26]? What are the implications of RSS for the syndication of content already expressed as METS and IMS-CP? These questions merit further investigation.

Conclusions

Work to translate between METS and IMS-CP is at an early stage. This article illustrates how a simple METS document can be translated into an IMS-CP version via an XSLT crosswalk. Although there is a great similarity between the two standards at the highest level, certain conceptual and practical differences distinguish documents implementing the two standards. The close comparison between METS and IMS-CP presented in this article suggests many needed refinements to the crosswalk. Including descriptive and administrative metadata translations in the crosswalk would be one such refinement. The development of profiles for METS and IMS-CP will make the task of writing crosswalks more focused and tractable. Ultimately, there will be a need to synthesize such crosswalks with efforts to create semantic interoperability among the full range of XML specifications in use in the library and educational communities.

Notes

1 Available at: www.imsglobal.org/DLims_white_paper_publicdraft_1.pdf
2 Available at: www.loc.gov/standards/
3 Available at: www.diglib.org/
4 Available at: www.imsglobal.org/content/packaging/cpv1p1p3/imscp_infov1p1p3.html#1519896
5 Available at: www.loc.gov/standards/mods/
6 Available at: www.loc.gov/standards/mix/
7 Available at: http://iu.berkeley.edu/crosswalk/Filer/filetree/libraryhitech/figure1.xml and http://iu.berkeley.edu/crosswalk/Filer/filetree/libraryhitech/figure2.xml
8 Available at: http://sunsite.berkeley.edu/xdlib/servlet/archobj?DOCCHOICE=metstest%2FSimpleMETS.xml
9 Available at: http://ltsc.ieee.org/wg12/
10 Available at: http://iu.berkeley.edu/crosswalk/Filer/filetree/libraryhitech/figure3.xsl
11 Available at: http://library.csun.edu/mwoodley/dublincoreglossary.html
12 Available at: www.w3.org/2000/06/webdata/xslt?xslfile=http%3A%2F%2Fiu.berkeley.edu%2Fcrosswalk%2FFiler%2Ffiletree%2Flibraryhitech%2Ffigure3.xsl&xmlfile=http%3A%2F%2Fiu.berkeley.edu%2Fcrosswalk%2FFiler%2Ffiletree%2Flibraryhitech%2Ffigure1.xml&transform=Submit
13 Available at: www.imsproject.org/content/packaging/cpv1p1p3/imscp_bindv1p1p3.html#1520279
14 Available at: www.imsproject.org/metadata/imsmdv1p2p1/imsmd_bindv1p2p1.html#1184108
15 Available at: www.cancore.ca/faq.html#application%20profile
16 Available at: www.loc.gov/standards/mets/profile_docs/mets.profile.v1-0.xsd and http://www.loc.gov/standards/mets/profile_docs/METS.profile.requirements.rtf
17 Available at: www.cetis.ac.uk/content/20030702184848
18 Available at: www.cancore.ca/
19 Available at: www.adlnet.org/
20 Available at: www.reload.ac.uk/
21 Available at: www.cancore.ca/documents/semantic.html
22 Available at: http://web.mit.edu/simile/www/
23 Available at: www.xml.com/lpt/a/2002/12/18/dive-into-xml.html
24 Available at: www.kottke.org/03/08/030806refined_rss_.html
25 Available at: www.xml.com/pub/a/2003/08/20/dive.html and www.xml.com/pub/a/2003/07/30/practicalRDF.html
26 Available at: www.intertwingly.net/wiki/pie/Motivation and http://blogs.law.harvard.edu/tech/rss

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Heflin, J. and Hendler, J. (2000), *Proceedings of Extreme Markup Languages 2000*, Graphic Communications Association, Alexandria, VA, pp. 111-20.