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Abstract

This research aims to find out the effect of syntax on interoperability among metadata standards. The interoperability of "MARC21 in XML (MARCXML)", "Metadata Encoding and Transmission Standard (METS)", "Metadata Object Description Schema (MODS)", "Metadata Authority Description Schema (MADS)", "Dublin Core Metadata Initiative (DCMI)", "PREservation Metadata: Implementation Strategy (PREMIS)", "Technical Metadata for Text (TextMD)", and "Metadata for Images in XML (MIX)" are examined. The first section of the paper describes the tools and types of interoperability among metadata standards. In the second section, METS is selected as a core standard. Finally, models of how the studied metadata standards interact with each other and with METS, based on an analytical-systematic approach, are investigated, and some patterns adapted with each model are planned. The results show that the use of appropriate syntax plays a key role in interoperating metadata standards, and leads to information system integration.

Keywords: Syntax, Metadata standards, Interoperability, Integration, Information systems

Introduction

Interoperability has been a fundamental requirement of the current information systems environment for over 20 years (Sheth, 1999). It implies the capability of interaction among multiple information systems with the aim of data exchange and services. The process of interoperability occurs in line with internal and external integration of information systems with their inner parts and other information systems, and results in added value for existing systems in the process. This interaction occurs at two levels: syntactic and semantic (Sinaci, 2014). At the syntactic level, data exchange is based on common formats or use of communication protocols; and at the semantic level, it is based on interpretation of exchanged data in a meaningful manner in order to produce useful results consistent with the needs and cognitive level of the users. Since the traits and characteristics of each content object (input) are described (or processed) in the form of standards and metadata schemata in a meaningful manner, and are represented in a new product called metadata records, the metadata is regarded as an information system. Thus, like other information systems, the need for interaction among metadata systems to achieve the aims of the interoperability process is obvious, and it is known as "metadata interoperability" which is a kind of semantic interoperability.

In other words, regarding the wide range of content published in each of the human knowledge areas, and the variety of services which have been made possible with the help of developments in the field of information and communication technologies to present these objects, as well as supporting particular functions by each of the metadata standards, it is essential to benefit from a range of the metadata standards to manage the content objects and services presented in information systems (National Information Standards Organization (NISO), 2004). Besides, the interoperability of these standards is necessary in order to integrate the parts and processes of the information system.

In recent years, extensive theoretical and practical efforts have been made to perform and facilitate the interoperability process of information systems, particularly metadata systems. These studies have focused on different aspects of interoperability, including semantic Interoperability in Global Information Systems (Ouksel and Sheth, 1999), interoperability

between metadata standards (Nogueras-Iso, 2005), automatic creation of crosswalk for geospatial metadata standard interoperability (Yang and Feng, 2012), event-based approach for semantic metadata interoperability (Ruotsalo and Hyvönen, 2007), approaches and standards for metadata interoperability in distributed image search and retrieval (Tous et al. 2011), changing focus on interoperability in information systems (Sheth, 1999), FSMI: MDR-Based Metadata Interoperability Framework for Sharing XML Documents (Na and Choi, 2005), new methods for enhancing the effectiveness of the Dublin Core metadata standard using complex encoding schemes (Szakadat et al. 2005), and Integration and Interoperability (Health Information Systems Programme (HISP)).

However, metadata requires syntax to represent itself. The machine-readability and machine-understandability of metadata is dependent on using syntax (Taheri et al., 2013). Therefore, some issues are raised here: Does syntax affect the interoperability of metadata standards? Does interaction among metadata standards occur at the syntax level? Will the selection of different syntax change the interoperability process? Can this syntax provide the grounds for the optimized management of the metadata and, subsequently, the content objects as the main objective of the integrity of information systems?

In the next section of this manuscript, after reviewing the Methodology, we aim to answer the above issues.

Methodology

This study examines the impact of syntax on the interoperability of metadata standards. The subjects include "MARC21 in XML format (MARCXML)", "Metadata Encoding and Transmission Standard (METS)", "Metadata Object Description Schema (MODS)", "Metadata Authority Description Schema (MADS)", "Dublin Core Metadata Initiative in XML format (DCXML)", "Preservation Metadata: Implementation Strategy (PREMIS)", "Technical Metadata for Text (TextMD)", and "Metadata for Images in XML (MIX)".

In the first section of the study, various tools used in the interoperability process are described, emphasizing the type of interoperability created among metadata standards. The next and main section of the study explains the impact of syntax on the interoperability of metadata standards. In this section, interaction of the standards with each other and with "Metadata

Encoding and Transmission Standards" is investigated with an analytical approach. METS is chosen due to its capability of metadata management and possibility of embedding other metadata standards inside it, through its sevenfold sections. In addition, the communication elements used for interaction among standards based on the studied standards are determined. The library research method was used to collect data, and the provided interaction patterns were designed based on the analytical-systematic approach.

Variety of tools for interoperability of metadata standards

As mentioned before, interoperability among information systems leads to their internal and external integrity, and brings numerous added values for these systems. Metadata interoperability is the ability of systems, services, and organizations to interact with one another, exchange data, and use the exchanged data with no need for any special effort from the source system. This process is done at three levels: 1) schema level, at which the metadata elements are considered, which is independent of the technical environment (network, hardware, and software). The products of this level of the process include a set of extracted elements, crosswalks, application profiles, and metadata registries; 2) interoperability of metadata records. At this level, the integration of the metadata records occurs through the mapping of elements according to their semantic meanings. The converted records, and new records produced, combined with the values of the existing record elements, are considered as the output of the record level; 3) repository level, at which the strings of the values of some special elements are extracted by harvesting data from different systems, and integrating them. This level provides the possibility of an integrated search among several information systems (National Information Standards Organization (NISO), 2004; Maarof and Yahya, 2009; Hirwade, 2011;).

A range of tools has been designed to carry out the metadata interoperability process. Application profiles, linking devices, crosswalks or mapping tables, and syntax are considered as tools for metadata interoperability. Application profiles are a set of metadata elements (extracted from one or more metadata standards), policies, best practice, and guidelines which are defined for special (local) applications. They state the rules which an organization, an information resource, an application, or a user community use in applying their metadata (the Dublin Core Metadata Initiative, 2018), and support the interoperability of the schema level. Linking devices refer to the traits or characteristics of the primary content object such as subject, author,

publisher, and the like which establish a link (relationship) among several content objects and lead to interoperability at the record level, as well as the repository level. Crosswalks or mapping tables refer to those tables which show the equivalent elements in more than one metadata standard, and like application profiles, permit interoperability at the schema level.

As with syntax, interoperability of metadata standards is done at schema level. Each metadata standard contains a special schema on which validation of compatibility of the produced records is based. Metadata standards are a set of semantically related and structured elements which have been designed to support specific functions consistent with the needs of their user community (National Information Standards Organization (NISO), 2004). These standards adopt one or more storing formats and data display formats as the syntax through which to implement records. There is a wide range of storing formats, some of which are database-based and others of which are file-based. The most important of these formats include markup languages (SCML, HTML, and XML), Portable Document Format (PDF) which uses Resource Description Framework (RDF)/XML, Text format, and the native format of metadata management systems (DBMS) (Taheri and Hariri, 2012). Each of these formats has specific capabilities for storing and displaying data, and has been produced based on particular purposes. Hence, their selection by metadata standards should be compatible with their specific functions.

In addition, since information systems use some metadata standards simultaneously to manage their content and services, interaction among these standards is essential in achieving the aims of the system. Thus, this feature is also important in the selection of syntax.

Hypertext Markup Language (HTML) is a format for describing the structure of Web pages in order to display them. The most important capabilities of this language are the possibility of using hyperlink technology and storing multimedia data. However, in designing this format, data transmission was not considered. That is why the number of HTML tags and metatags is limited and pre-determined, and cannot be extended. The description of data stored in this format is dependent on the software features of the information system which uses HTML. This feature limits the interaction of metadata standards which recommend the implementation of their records in the syntax of this language (Word Wide Web Consortium, 2018).

Portable Document Format (PDF) has been designed to represent content objects independently of the hardware, software, and operating system. When preserving the layout features of a digital or analog object stored in another electronic format is the primary consideration, PDF format is used (Wikipedia, 2018). Therefore, one of the best formats for printing content objects is PDF. PDF format can be used for implementing metadata records by RDF/XML. Although this format is platform-independent since it preserves layout features, data stored in it is not described semantically, and is merely regarded as an image of the object converted to PDF. In other words, in transmitting data from one system to another, the structure of the data cannot be processed, and PDF's main aim is to display the data, just like HTML format. Since in metadata records, meaningful description of the elements and their relationships is of great importance, this format is not highly considered in the metadata context.

Text format has been designed to store data without using any marks or special structured acts. Data stored in this format occupy very little volume due to the absence of any additional marks in it. In some cases, by adding some marks to data stored in this format, special processes can be applied to it. The main disadvantage of this format in the interoperability process is its lack of structure and lack of description of the data stored in it.

The native formats of Database Management Systems (DBMS) are consistent with each system's technical features and capabilities, as each format is designed based on the system's unique purposes and functions. Data stored in the native format of one DBMS cannot be processed in another unless it is converted to that system's format. Due to the fact that information systems use a special platform, and as a result, different DBMS, the use of native formats in the process of intersystem interaction is limited.

EXtensible Markup Language (XML) is a simple text-based format which has been extended as an international standard to represent structured data such as content objects, to exchange and to share data (Bray et al, 2008). Data marked in XML format is converted to structured data and creates self-description content objects. This feature causes independence of XML-based content objects from each platform and allows their exchange among heterogeneous systems. Thus, it causes interoperability among information systems. XML, unlike HTML, is not a fixed set of tags. Using this standard, users can define their required tags and use them in other information

environments. The unique capabilities of this markup language mean that designers of metadata standards tend to use XML as the syntax of metadata records. Additionally, implementation of some standards such as MARC 21, which was not possible in markup language format, has been made possible in such languages using XML (Qin, 2000; Gigee and kely, 2006; Taheri, 2008). Its structure and self-description features have facilitated the interoperability of systems and metadata standards (Taheri, 2012).

In the next part of the article and in designing several patterns, the impact of syntax on metadata standard interoperability, which justifies the possibility of using a range of standards in an information system simultaneously, is investigated with an analytical-systematic approach.

Explaining the impact of syntax on the interoperability of metadata standards

In this section, using Metadata Encoding and Transmission Standard (METS) as a core standard, the interoperability of other metadata standards with this standard, and if necessary, the interaction of other standards with each other, is shown by providing patterns. The reason behind selecting METS as the core standard is its main function, that is, metadata management (Taheri, 2008). METS acts like a package that can wrap other metadata standards with various functions, and deal with the integrated management of content objects.

METS contains seven sections, each with a specific function. Some are designed for wrapping metadata schemata, and some for managing content. Meanwhile, all of these sections are able to interact with each other, and their interoperability adds to the importance of METS. These sections are the METS header section, the descriptive metadata section, the administrative metadata section, the file section, the structured links section, and the behavior section (Network Development and MARC Standard Office, 2018c). The interaction of each of the standards occurs through the relational elements and in the form of METS' seven sections. Each metadata record establishes interaction with the METS record through two methods. First, the internal method in which the mentioned record is embedded within the METS record in two ways: data encoded by XML (by the tag <xmldata>) and data based on binary codes or the raw text (by the tag <bindata>). Second, through the provision of the link (through a record's URI or other identifiers like PURL, ARK, and DOI) from within the METS-related element to the metadata record based on another metadata standard. It should be noted that it is possible to embed records

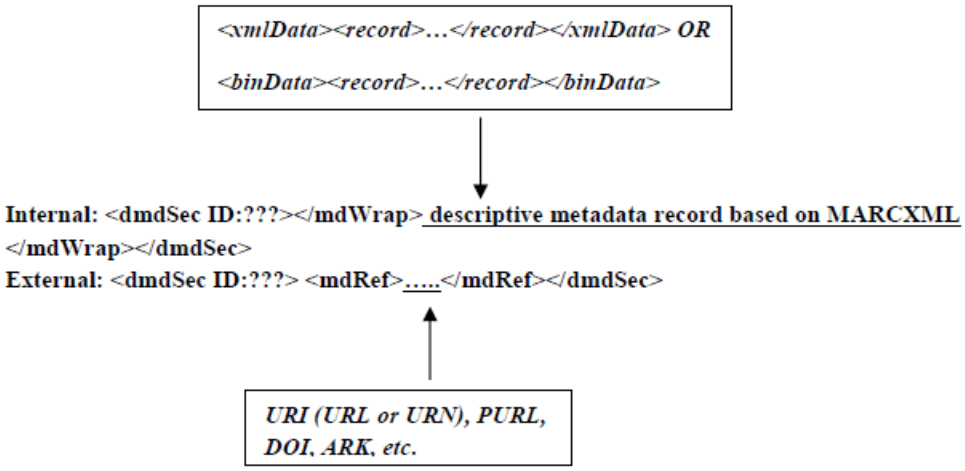
based on more than one standard in each section. The records produced based on each metadata standard contain one root element. This element plays the role of the relational element to relate with the METS records. Next, the interaction method of each of the standards and their relational element are analyzed.

MARC 21 in XML (MARCXML)

This metadata format was designed by the Network Development and MARC Standard Office (NDMSO) of the Library of Congress in order to implement MARC data in XML syntax. The flexibility and extensibility of this framework has made it possible to meet numerous specific needs of users (Network Development and MARC Standard Office, 2018a). The existence of various elements caused MARC format to support some functions effectively. The main functions of MARC are both administrative and descriptive. Below, the interoperability method of MARCXML has been depicted based on the administrative and descriptive functions by METS.

- As descriptive metadata

The root element (<record>) of MARCXML-based metadata records which supports the descriptive function is embedded within the element <dmdSec> of the METS descriptive metadata section in the tag <mdRef> based on the internal method, and links to a MARCXML record based on the external method in the tag <mdRef>. If the internal method is considered, data encoded in XML format is embedded within the tag <xmldata>, and data in the binary format or raw text format is embedded in the tag <bindata>. Other metadata standards with the description function also establish interaction with METS in the same way.

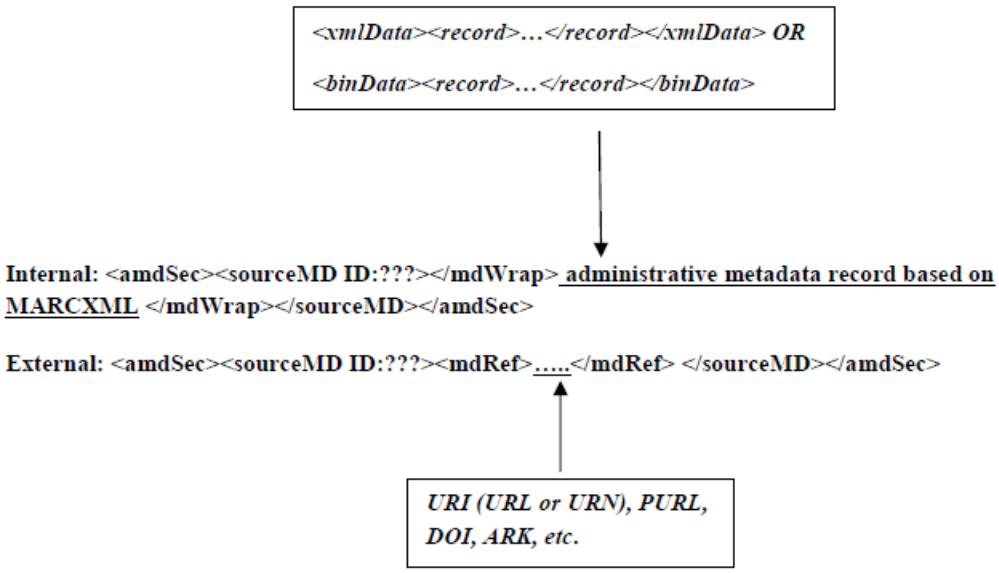


Pattern 1. Method of embedding a MARCXML record with a descriptive function in the descriptive metadata section of a METS record

Pattern 1 shows that the root element of a MARCXML record is able to embed respectively within the elements <dmdSec ID:???>, </mdWrap> or <mdRdf>, <xmlData> or <binData>, and <record> to support the descriptive function.

- As administrative metadata

The root element of a MARCXML record with an administrative function is embedded in the administrative metadata section of METS with the tag <admSec> based on the internal method in the tag <mdWrap>, and links to a MARCXML record based on the external method in the tag <mdRef>. Records based on metadata standards with the administrative function in the tag <techMD> (for metadata standards with the technical function), <rightsMD> (for metadata standards with the intellectual property rights administration function), <sourcMD> (for metadata standards with administrative and descriptive functions related to analog objects) and <digiprovMD> (for metadata standards with the digital born administration function) METS are embedded. Other metadata standards with administrative function interact with METS with regard to their specific sub-function like MARCXML.

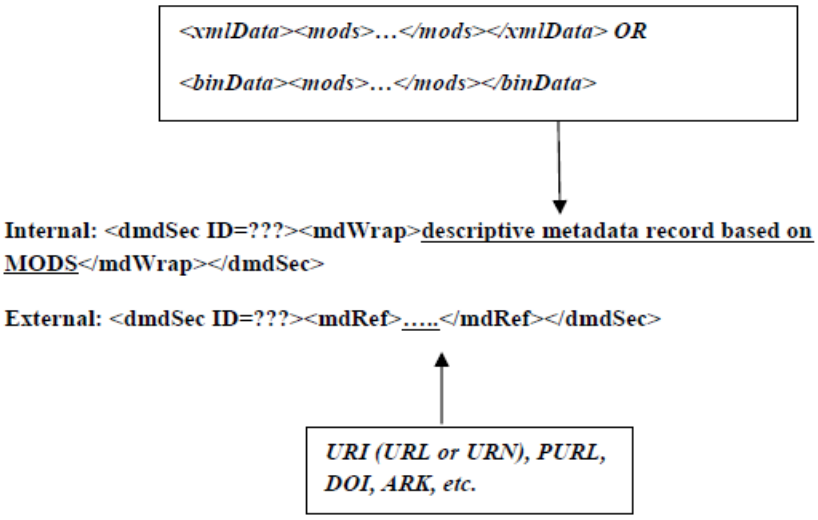


Pattern 2. Method of embedding a MARCXML record with the administrative function in the administrative metadata section of a METS record

As seen in Pattern 2, the MARCXML record can be embedded respectively in the tags <amdSec ID:???>, </mdWrap> or <mdRdf>, <xmlData> or <binData>, and <record>

Metadata Object Description Schema (MODS)

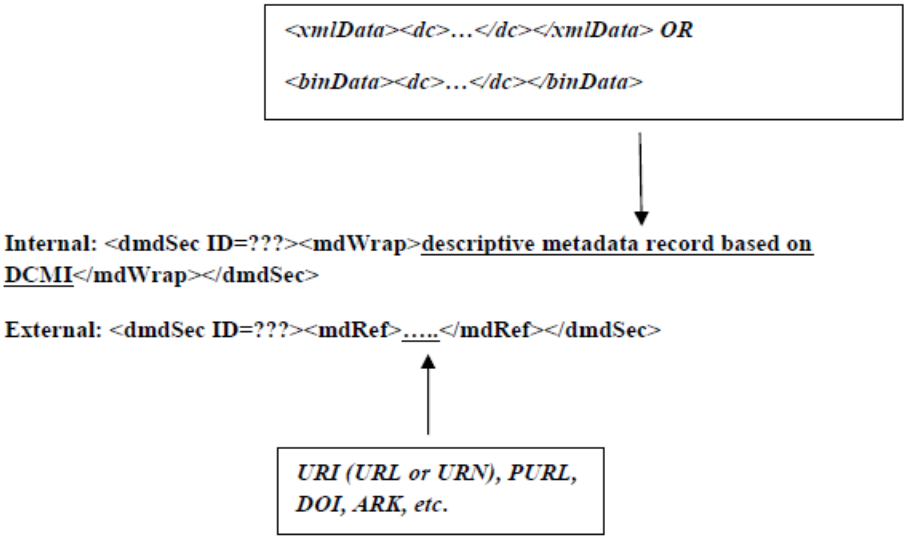
This standard is provided in XML syntax for a set of bibliographic elements which are used with various purposes, especially library applications. MODS provides the possibility of carrying selected data from existing MARC 21 records and creating original descriptive records for the new content objects. It includes a required subset of MARC elements (fields) for describing digital objects and uses selected data from existing MARC 21 records (McCallum, 2004; Network Development and MARC Standard Office, 2018e). The MODS main function is descriptive and so its records are embedded in the METS descriptive metadata section.



Pattern 3. Method of embedding a MODS record in a METS record descriptive metadata section

Dublin Core Metadata Initiative (DCMI)

This is an international and interdisciplinary schema which provides a set of simple and efficient elements for description of a wide range of content objects. The main function of the Dublin core schema is descriptive. XML is one of the Dublin core formats, and it is possible to implement DC records in other formats (Johnston and Powell, 2006; National Information Standards Organization (NISO), 2004)



Pattern 4. Method of embedding a DC record in a METS record descriptive metadata section

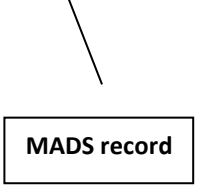
Metadata Authority Description Schema (MADS)

MADS consists of a set of elements for the description of the authority date related to agents (people, organizations), events, and terms (topics, geographics, genres, etc.). It was designed as a companion to the Metadata Object Description Schema (MODS) to provide metadata about the authoritative entities used in MODS descriptions (Network Development and MARC Standard Office, 2018b). However, it can be used to authorize the element values of other metadata standards. MADS is not embedded directly in, or linked to the METS header; however, it interacts with METS indirectly and is linked to the records of other metadata standards.

<?xml version="1.0" encoding="UTF-8"?><mads xmlns=http://www.loc.gov/mads/ xmlns:mods="http://www.loc.gov/mods/v3" xmlns:xlink="http://www.w3.org/1999/xlink" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:schemaLocation="http://www.loc.gov/mads/mads.xsd"> <authority><name><namePart>Smith, John</namePart><namePart type="date">1995- </namePart></name></authority><variant type ="other"><name><namePart>Smith, J</namePart></name></variant> <variant type="other"><name><namePart>Smith, John J</namePart> </name></variant><note type="history">Biographical note about John Smith.</note><affiliation><organization>Lawrence Livermore Laboratory</organization><dateValid>1987</dateValid></affiliation></mads>

Sample 1. A sample record of MADS related to a person

Internal: <dmdSec ID=???><mdWrap><mods><name type="personal"> <namePart type="termsOfAddress">Dr.</namePart> <namePart>*Smith, John*</namePart> </name></mods></mdWrap></dmdSec>



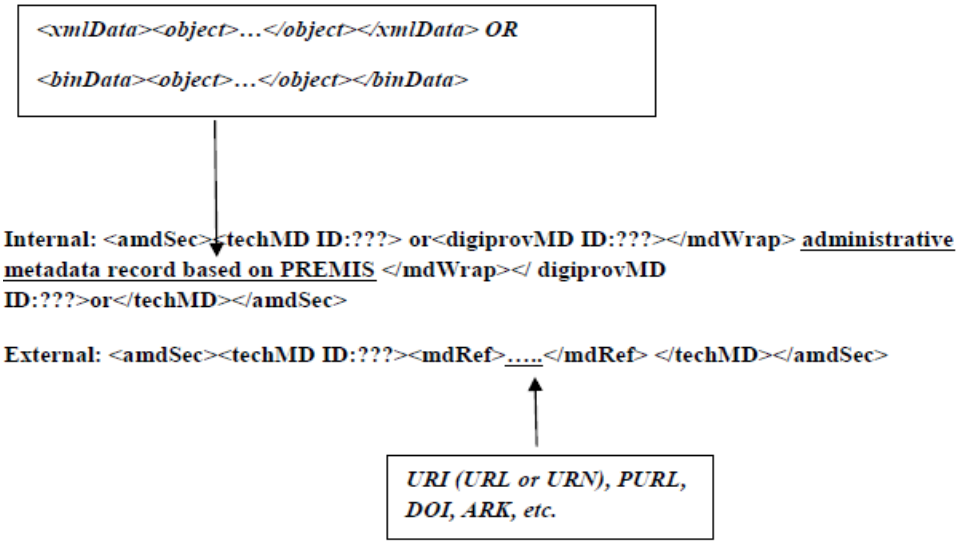
Pattern 5. Method of indirect interaction of a MADS record with a METS record through a MODS record

The MADS record in the authority file is linked by the record identifier with the relational element (field) of the MODS record in the bibliographic file which only accepts encoded values.

Therefore, a direct link is established between the MADS and MODS records, and an indirect link between the MADS and METS records.

PREservation metadata: Implementation Strategy (PREMIS)

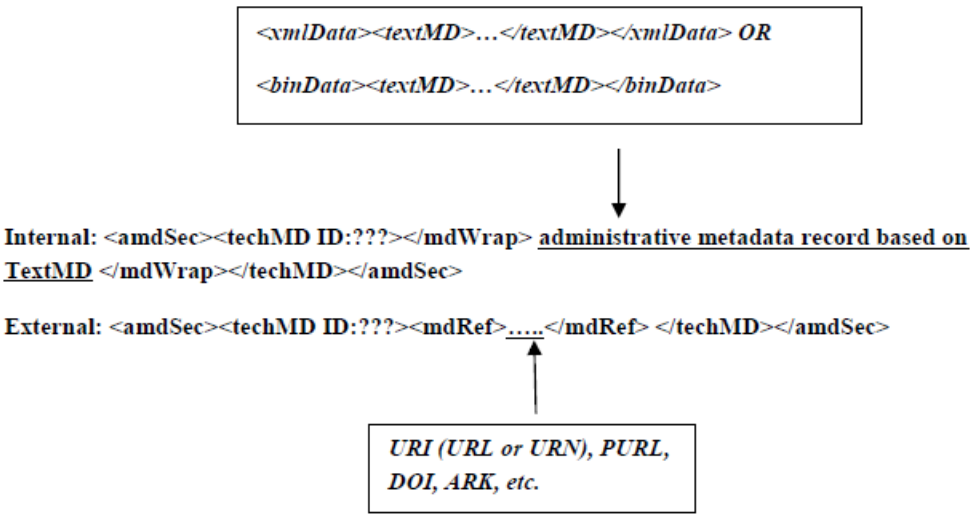
A set of XML-based elements has been extended with the aim of registering metadata associated with the preservation of digital content in libraries or other digital collections. Thus, the function of PREMIS is to preserve digital objects (Habing, 2008). PREMIS records should be embedded in the METS administrative metadata section and in the tags (elements) <techMD> and <digiprovMD>, based on the kind of entity they contain.



Pattern 6. Method of embedding a PREMIS record in a METS record administrative section

Technical Metadata for Text (TextMD)

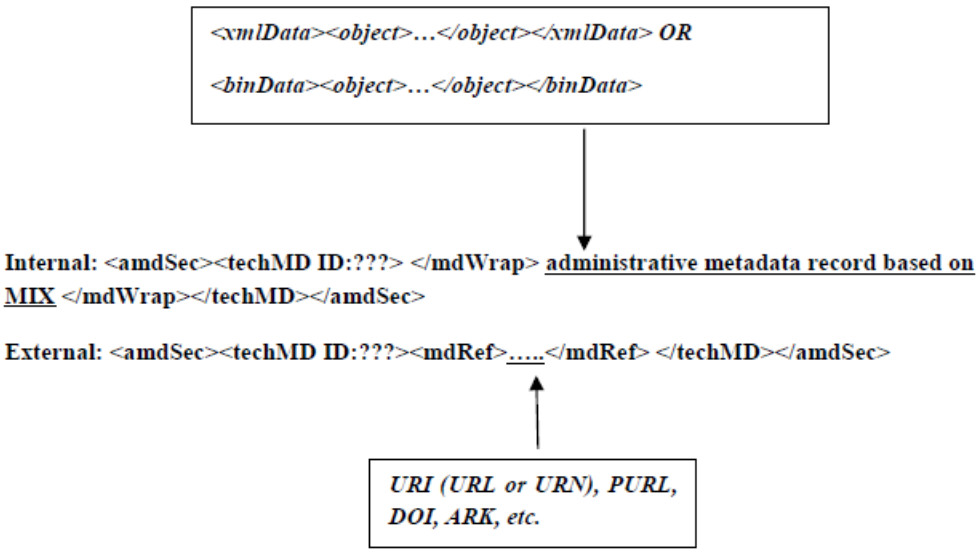
An XML-based metadata standard which provides elements for the description of the technical aspects and features of textual digital objects. TextMD records can be embedded directly in the METS administrative metadata section, or indirectly in the element <additionalTechnicalCharacteristics> related to the object entity of PREMIS (Network Development and MARC Standard Office, 2018f).



Pattern 7. Method of embedding a TextMD record in the METS record administrative metadata section

Metadata for Images in XML (MIX)

MIX is being developed by the Network Development and MARC Standards Office (NDMSO), in partnership with the NISO Technical Metadata for Digital Still Images Standards Committee, to manage still digital image collections. The main function of this standard is the technical management of digital images (Network Development and MARC Standard Office, 2018d). MIX records can be embedded in the METS administrative metadata section in the element <techMd>.



Pattern 8. Method of embedding a MIX record in the METS administrative metadata section

As seen in the designed patterns, the syntax of the studied metadata standards provides the possibility of interoperability among them. Each standard can relate with each other and with the METS core standard, making integration of information systems possible with the support of a variety of functions. Besides, more than one metadata standard with a similar function can be embedded in a METS records (when more than one standard or a selection of the elements of each standard is required). The application profile of a specific information system or environment can also be packaged in METS records. The studied standards were only some (the most important and most widely used) of the available metadata standards. Obviously, the interoperability of other standards would be possible using appropriate syntax. This shows the impact of syntax on interoperability among metadata standards.

<metsHdr CREATEDATE="2013-01-05T14:00:00" RECORDSTATUS="Complete"><agent ROLE="CREATOR" TYPE="INDIVIDUAL"><name>Sayyed Mahdi Taheri</name></agent></metsHdr>

<dmdSec ID:???></mdWrap> descriptive metadata record based on MARCXML </mdWrap></dmdSec><dmdSec ID=???><mdWrap>descriptive metadata record based on MODS../../../Documents and Settings/HRT/My Documents/Downloads/Examples/mods99042030.xml**</mdWrap></dmdSec><dmdSec ID=???><mdWrap>descriptive metadata record based on DCMI**../../../Documents and Settings/HRT/My Documents/Downloads/Examples/mods99042030.xml**</mdWrap></dmdSec><amdSec><sourceMD ID:???></mdWrap> administrative metadata record based on MARCXML </mdWrap></sourceMD></amdSec><amdSec><techMD ID:???> or<digiprovMD ID:???></mdWrap> administrative metadata record based on PREMIS </mdWrap></ digiprovMD ID:???>or</techMD></amdSec><amdSec><techMD ID:???></mdWrap> administrative metadata record based on TextMD </mdWrap></techMD></amdSec><amdSec><techMD ID:???> </mdWrap> administrative metadata record based on MIX </mdWrap></techMD></amdSec><fileSec><fileGrp ID="VERS1"><file ID="FILE001" MIMETYPE="application/xml" SIZE="257537" CREATED="2018-01-05"><FLocat LOCTYPE="URL">http://dlib.nyu.edu/tamwag/beame.xml</FLocat></file></fileGrp></fileSec><structMap TYPE="logical"> <fptr FILEID="FILE001"><area FILEID="FILE001" BEGIN="INTVWBG" END="INTVWND" BETYPE="IDREF"/></fptr> </structMap> <fptr FILEID="HTMLF1"/> <fptr FILEID="JPGF1"/> <METS:behavior ID="DISS1.1" STRUCTID="S1.1" BTYPE="uva-bdef:stdImage" CREATED="2002-05-25T08:32:00" LABEL="UVA Std Image Disseminator" GROUPID="DISS1" ADMID="AUDREC1"><METS:interfaceDef LABEL="UVA Standard Image Behavior**

Definition" LOCTYPE="URN" xlink:href="uva-bdef:stdImage"/><METS:mechanism LABEL="A NEW AND IMPROVED Image Mechanism" LOCTYPE="URN" xlink:href="uva-bmech:BETTER-imageMech"/></METS:behavior>

Pattern 9. The resultant pattern: A complete METS record which contains all the studied standards

Conclusion

The necessity of using several metadata standards in an information system in order to support its various functions, and the special attention paid by information systems designers to integration, indicates the importance of interoperability among metadata standards. Designing application profiles consistent with the needs of specific information systems or environments has also doubled this important issue. Syntax is a key factor in interoperability among metadata standards. By selecting appropriate syntax, metadata standards enhance their interaction level with other metadata standards. This encourages information systems to select them. This also explains the tendency of metadata standards to select XML as the main format or one of the record implementation formats, due to its unique capabilities such as its self-description which facilitates the interoperability process at both syntactic and semantic levels (Taheri et al., 2013).

Syntax prepares the ground to support the intended functions of metadata standards, and to relate metadata standards to each other (Haslhofer et al., 2010). In addition to improving the internal integration of information systems, it improves their interoperability with other information systems (external integration) such as Web search engines as the most widely used tool for searching information in the Web (Tous, 2003; Qin, 2008; Taheri and Hariri, 2012; Taheri et al., 2014). The possibility of integrated access to content objects stored in various information systems through tools such as information gateways and portals is one of the benefits of syntax capabilities. The other added value which a proper syntax will produce is knowledge creation based on relationships among metadata records, which is another manifestation of the internal and external integration of information systems.

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