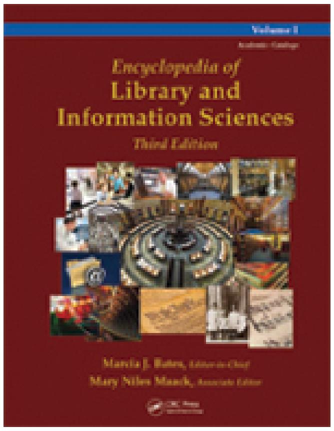

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Metadata and Digital Information

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Abstract
The range of metadata activity over this last decade is both extensive and astonishing, and substantiates metadata as an integral part of our digital information infrastructure. This entry begins with a brief history of metadata relating to digital information, followed by an overview of different metadata types, functions, and domain-specific definitions. Next, the family of standards comprising a metadata architecture are defined, followed by an overview of metadata generation processes, applications, and people: this latter section gives particular attention to automatic metadata generation approaches. The following section explores four key metadata models. The conclusion summarizes the entry, highlights a number of significant metadata challenges, and notes efforts underway to address metadata challenges in the new millennium.

INTRODUCTION

Today one can hardly talk about digital libraries, data repositories, and many aspects of the library 2.0/web 2.0 environment without mention of *metadata*. This is because metadata is a crucial part of these digital information systems. Metadata describes information and its context and associations; it is integral to the operation and function of any system preserving and supporting discovery, access, and use of information. Metadata is also a necessary component of physical information systems, such as the traditional library card catalog. In this context, bibliographic records (an equivalent of *descriptive metadata*) represent library holdings and facilitate resource discovery and use.

The first article on "metadata" appearing in the *Encyclopedia of Library and Information Science (ELIS)* was published in 2002,[1] under the title, "Metadata and the World Wide Web." This work was revised and republished in 2003.[2] These noted entries define metadata, compare metadata to library cataloging, describe concepts for discussing metadata, and review different methods for generating metadata.

Metadata developments have matured considerably since these first *ELIS* entries were published, and a number of initially ambiguous aspects surrounding the topic are more fully understood. For example, when the term metadata was first being explored in the library community, via digital library and World Wide Web (web) development, there were efforts to distinguish metadata from library catalog data, including MAchine Readable Cataloging (MARC) bibliographic data. Today, library catalogers and digital library professionals generally agree that MARC bibliographic data is metadata, and that the family of MARC formats—bibliographic, authority control, and so forth[3,4]—all have a place within metadata discussions. Another sign of growth is that metadata-related development and inquiry has expanded well beyond National Information Standards Organization (NISO) and the International Standards Organization (ISO) metadata standards to include ontologies,[5,6] the Semantic Web,[7] annotation,[8] and social computing/web 2.0 developments relating to tagging and folksonomy.[9,10] In short, our perception and comprehension of metadata has been influenced by time and the evolution of technology and information practices requiring metadata.

This encyclopedia entry considers the evolution of metadata and presents a fresh perspective on this topic. The rest of the entry is organized by the following section headers: "Metadata: Origin and History" covers the origin and history of metadata relating to digital information; "Defining Metadata" explains the different types and functions of metadata and presents a series of domain-specific definitions for metadata; "Metadata Standards" defines the family of metadata standards that comprise a metadata architecture—these include data structure standards, content value standards, data communication standards, and syntax standards; "Metadata Generation" reviews metadata generation, processes, applications, people—giving focused attention to automatic approaches; "Metadata Models" explores several key metadata models; and the "Conclusion" summarizes the entry, and highlights several significant metadata challenges being faced in this new millennium.

METADATA: ORIGIN AND HISTORY

The etymology of metadata draws from the classical Greek prefix *meta*, which means "after, behind, or

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higher;" and the from Latin word *data*, plural for datum, which means "a piece of information" or "something given."[11] Metadata is, in essence, a piece of information generated *after* the object of focus has been produced; and the information given is at a higher level (more abstract) than the object.

Metadata, as an information concept, is known to have first been used in the late 1960s by individuals in the statistics/database community, and it has been recollected that it was a standard word by the 1970s, although references are difficult to find. The first known reference appears in *An Infological Approach to Data Bases*, a doctoral dissertation completed in 1973, by Bo Sundgren, at the Statistiska Centralbyren (pp. 104–105).[12] This work also includes the concept of *metainformation* and articulates distinctions between the real-world phenomena; information about phenomena; and data representing the information describing the phenomena; the last conception is referred to as meta-metadata in today's information systems.

The most frequent historical reference given for *metadata* is for a marketing brochure, printed for Jack E. Myers, representing a MetaModel and company products. References credit Meyers with coining the term *metadata* in 1969,[13] and in 1986 METADATA® was registered as an United States trademark for The Metadata Company (http://www.metadata.com/), where Meyers is a principal. Meyers is known to have legally contested the use of term *metadata* by others. However, his ownership claims have been successfully refuted, given the publication of *An Infological Approach to Data Bases* and the longstanding historical use of this term in the statistics community.

Today, the term metadata has been steadfastly integrated into our information culture, and it is generally, although not exclusively, associated with digital information. Evidence of growth includes the increase in people engaged in metadata work in the library and other information intensive environments, such as scientific research centers. As part of this growth we see professional titles like *metadata librarian* and *metadata specialist*. The body of scholarly research on metadata is also expanding; in fact there are two fairly new scholarly journals targeting metadata: *The International Journal of Metadata, Semantics and Ontologies* (http://www.inderscience.com/ijmso) published by Inderscience Publishers, and *Journal of Library Metadata* (http://www.tandf.co.uk/journals/) published by Taylor & Francis. Additionally, the number of books on metadata continues to grow yearly, with very recent notable publications by Riley and Foulonneau,[14] Zeng and Qin,[15] and Liu.[16] Finally, a factor of growth is the Dublin Core Metadata Initiative (DCMI) (http://www.dublincore.org/), which has been flourishing since 1995, promoting the Dublin Core Metadata Element Set (DCMES),[17] an open, interoperable, interdisciplinary metadata standard. The DCMI and metadata initiatives in the education, science, government, industry, and other communities have been a major force bringing metadata issues to the forefront of library and information science, and demonstrate the wide reach and complexity of this topic.

DEFINING METADATA

Definitions for metadata have been influenced by both the objects to which the metadata is being applied, and the functions it is intended to support. The most often uttered and most inclusive definitions for metadata are *data about data* and *information about* information. Although *data* and *information* can have distinct meanings,[18] these terms are frequently used interchangeably, and it is not uncommon for metadata to be also defined as *information about data*, or even *data about information*. What makes these definitions high-level is that the "information" or "data" being described connotes an *abstract object*—that is "anything perceivable or conceivable," as defined in the ISO/IEC (International Organization for Standardization/International Electrotechnical Commission) 11179-1:2004, Metadata registries (MDR)—Part 1: Framework (p. 4).[19]

The earlier *ELIS* metadata entries give attention to the unbounded nature of an object as "any *entity*, *mode* or *form*" to which metadata can be applied, ranging from "information resources, such as a monograph, newspaper, or photograph—to activities, events, persons, places, structures, transactions, relationships, execution directions, and programmatic applications."[1,2] The ways in which people work with and understand information varies enormously across disciplines, cultures, and societal strata, and it follows that their conception of the information object varies as well.

Library and information science is primarily concerned with metadata for *information resources*—the types of *objects* housed in libraries, repositories, museums, archives, and other types of information centers. In this environment, metadata is frequently defined as "structured data about data."[20,21] The structured metadata is gathered to form a *metadata surrogate*—a "stand in" for the real resource akin to a bibliographic surrogate.

Metadata surrogates are usually comprised of *descriptive metadata*, which is metadata that supports resource discovery. Detailed, more granular metadata definitions, beyond data about data, emphasize types (or classes) of metadata and the associating functional aspects, such as describing, preserving, and contextualizing information (see Table 1).

Although literature confirms there is no single agreed upon typology of metadata types or functions, metadata discussions promote similar and overlapping labels and definitions (pp. 20–22).[22] Further, more granular

Table 1 Examples of metadata types, functions and properties

Type of metadata	Function supported	Metadata property (element)
Descriptive metadata	Resource discovery; selection; access	[a]Creator; title; subject
Preservation metadata	Resource management	Resolution; density; fixity
Provenance metadata	Lifecycle management; authentication	[a]Creator; date created; date modified
Contextual metadata	Awareness; comprehension; interpretation	Date created; temporal data; arrangement (placement of an object in relation to other objects)
Technical metadata	Use; access	System requirements; format
Rights management metadata	Access; reproduction; use/re-use	Rights

[a]A metadata property that can be labeled as more than one *type* of metadata is multifunctional.[22] The Dublin Core property *creator* is identified as "descriptive metadata" because it helps with discovery and "provenance metadata" because it helps with lifecycle tracking; creator is, therefore, a multifunctional property.

definitions are important because they provide insight into the functional aspect of metadata and the way in which different communities work with and understand metadata. The following community-oriented definitions illustrate this point more concretely:

- The *library community* emphasizes *descriptive metadata*; that is "metadata that serves the purposes of discovery (how one finds a resource), identification (how a resource can be distinguished from other, similar resources), and selection (how to determine that a resource fills a particular need, for example, for the DVD version of a video recording)" (pp. 210).[23,24]
- The *digital geospatial and environmental science communities* have consistently stated that "Metadata or 'data about data' describes the content, quality, condition, and other characteristics of data" (p. 1),[25] providing a definition reflecting needs of associated with digital geospatial and similarly related materials.
- The *business community* highlights metadata for *machine processing* and *user activities*, and adheres to two main metadata classes: *technical metadata* describing database information and machine driven tasks; and *business metadata* supporting input/output tasks overseen by humans (p. 12).[26]
- The World Wide Web Consortium (W3C) emphasizes the *computing potential* of metadata for growing the Semantic Web, and defines metadata as "machine understandable information for the web" (W3C Metadata and Resource Description: http://www.w3.org/Metadata/).
- The social networking and web 2.0 environment promotes the use of the term tag/tags/tagging instead of metadata. Definitions for these terms underscore the functional aspect of tags as "keywords" for *describing*, *classifying*, *finding*, and *sharing* information.[27]

These more descriptive definitions show a range of activities and functions metadata supports (e.g., retrieval, preservation, and machine processing). The range of definitions also provides insight into the complexity of this topic, and helps explain why, in many respects, the high-level definition of *data about data* is the accepted unifying definition, despite its generality.

METADATA STANDARDS

Metadata generally involves standards. The degree to which standards apply varies tremendously, depending on the object of interest, available technology, and community overseeing the metadata activity. Metadata activities in the library and information community are supported by a series of standards that comprise a metadata architecture. These include: *data structure standards*, *content value standards*, *communication standards*, and *syntax standards*. Although different aspects of these types of standards are generally integrated in a single metadata package, they are reviewed separately here to emphasize specific functions. Many instances of the standards reviewed here are endorsed by agencies, such as the American National Standards Institute (ANSI), National Information Standards Organization (NISO), International Organization for Standardization (ISO), Internet Engineering Task Force (IETF), and the World Wide Web (W3C), and designated by an identifier often consisting of numbers or numbers and letters.

Data Structure Standards

Data structure standards are the most familiar metadata standard. A data structure is essentially a list or container of explicit properties (elements). A data structure standard names and defines the *semantic categories* representing the information system's metadata. These semantic categories are most often referred to as *metadata elements*, although *metadata facets* are also becoming common. Most recently, the Dublin Core community has been promoting the term *metadata properties* in an effort to align metadata activities with the Semantic Web.

The DCMES, version 1.1 (here after referred to as the Dublin Core) is among the most internationally and interdisciplinary recognized metadata data structure standards. The Dublin Core and is defined as "a vocabulary of 15 properties for use in resource description,"[17] and is endorsed by the ISO (ISO 15836-2003), ANSI/NISO (ANSI/NISO Z39.85-2007), and the IETF via a request for comment (IETF/RFC 5013-2007). Examples of Dublin

Core properties include *creator*, *title*, and *subject*. An example for the property "creator" from the Dublin Core, 1.1, is provided in Example 1.

Example 1: Characteristics for the Dublin Core Metadata Property *Creator*

Term Name: Creator	
URI:	http://purl.org/dc/elements/1.1/creator
Label:	Creator
Definition:	An entity primarily responsible for making the resource.
Comment:	Examples of a Creator include a person, an organization, or a service. Typically, the name of a Creator should be used to indicate the entity.

Data structure standards are fairly equivalent to data dictionaries developed for databases and frequently include additional information about the use and application of metadata properties. For example, a data structure standard may recommend a *public label*; confirm property *cardinality*—if the metadata property is repeatable; declare property *obligation*—is property required, recommended, or optional; and list legal content values or standards for a property.

Data structure standards have been developed for a wide range of domains. Examples include following:

- *Metadata Object Description Schema* (MODS)[28] for digital library resources.
- *Visual Resources Association Core Categories* (VRA Core)[29] for visual resources.
- *Encoded Archival Description* (EAD)[30] for electronic finding aids.
- *Data Document Initiative* (DDI)[31] for social science research data.
- *Federal Geographic Data Committee/Content Standard for Digital Geospatial Metadata* (FGDC/CSDGM)[25] for digital geospatial resources.
- *Ecological Metadata Language* (EML)[32] for ecological research data.
- *Institute of Electrical and Electronics Engineers/Learning Object Metadata* (IEEE/LOM)[33] for digital learning objects.
- *PREservation Metadata*: *Implementation Strategies* (PREMIS)[23] for preservation information about any digital object.
- *Darwin Core* (DwC)[34] for specimen collections and the geographic occurrence of species.

The immediate above list includes only several of the hundreds, and potentially thousands, of metadata schemes that function as data structures. The widespread availability and increased sharing of schemes represents a maturity in metadata development; and it is simply *best practice* to first consider if a scheme (or schemes) fulfilling project needs has already been developed when embarking on any new initiative requiring metadata. Among incentives for adopting, and potentially modifying, existing metadata schemes are the desire to support interoperability and avoid duplicative efforts. Supporting this trend are *application profiles*,[35] which are data structures composed of defined properties from established standardized schemes. The DCMI has developed the Singapore Framework[36] to standardize the creation and documentation for application profiles.

Content Value Standards

Content value standards contain words, names, and symbols connoting meaning. Common types of content value standards include *subject heading lists*, *thesauri*, *classification systems*, *taxonomies*, *ontologies*, and *name authority files* (for people, places, geographical jurisdictions, and other named entities). Content value systems containing concepts used for topical, domain, or intellectual representation are increasingly referred to as knowledge organization systems (KOS).[37]

Values are drawn from content value standards and paired with properties to complete a metadata record; hence, the common notion of property/value pairs. For example, the Harley–Davidson Web site as *a digital resource* has various properties, such as title, subject, and date. These properties are defined in the Dublin Core, and assigned values to construct a metadata record. Example 2 presents a fragment of a Dublin Core metadata record showing *Library of Congress Subject Headings* (LCSH)[38] values in XML for the Harley–Davidson Web site.

Example 2: Fragment of a Dublin Core metadata record showing *LCSH* values in XML for the Harley-Davidson Web site

```
<dc:subject xsi:type="dcterms:LCSH" >Harley-Davidson motorcycle </dc:subject>
<dc:subject xsi:type="dcterms:LCSH" >Harley-Davidson motorcycle-Collectibles</dc:subject>
```

Content value systems are neither available nor desirable for every property defined in every metadata scheme; and the freedom to create content values via tagging is part of the appeal and success of folksonomies. In fact, one may argue that a folksonomy presents a de facto content value standard via sharing and aggregating agreed upon tags.

Data Communication Standards

Data communication standards are the encoding or markup language that wraps around the property/value pairs in the metadata record. Data communication standards permit metadata records to be stored, searched, retrieved, and exchanged with other information systems. The prescribed system of punctuation that is part of the International Standard Bibliographic Description (ISBD), and the other ISBD formats that have now been consolidated,[39] is an example of a pre-Web data communication standard. Developed in the late 1960s, with the eye toward supporting computer exchange of bibliographic data, the prescribed punctuation separates designated areas of description, such as resource "title" and "statement of responsibility."

Data communication standards commonly used today for encoding metadata include MARC bibliographic format (ISO 2709/ANSI/NISO Z39.2), which incorporates ISBD; eXtensible Hypertext Markup Language (X/HTML; W3C WD-xhtml2-20060726); and XML (W3C REC-xml-20060816). Example 3 presents a MARC bibliographic record with core properties and the XML Dublin Core equivalent for the same metadata.

Example 3: MARC Bibliographic Record and Dublin Core XML Metadata Record for Berners-Lee's book *Weaving the Semantic Web*

MARC Bibliographic record	Dublin Core XML record
100 1 Berners-Lee, Tim.	<dc:creator>Tim Berners-Lee </dc:creator>
245 10 Weaving the Web / $c Tim Berners-Lee with Mark Fischetti.	<dc:title>Weaving the Web </dc:title>
260 [San Francisco]:$b HarperSanFrancisco,$c c1999.	<dc:pulisher>HarperSanFrancisco </dc:pulisher>
300 xi, 226 p.;$c 25 cm.	<dcterms:created >1999</dcterms:created >
650 0 World Wide Web.	<dcterms:extent >xi, 226 p. and 25 cm </dcterms:extent >
700 1 Fischetti, Mark.	<dc:subject xsi:type= "dcterms. LCSH"> World Wide Web </dc:subject> <dc:contributor>Mark Fischetti</dc:contributor>

Syntax Standards

Syntax standards are not stand-alone standards designated by an identifier, rather they are integrated each of the standards reviewed, and guide metadata creation and encoding. For example, syntax standardization may dictate element ordering for data structure standards; value structuring for value content standards; and grammar for communication standards. (The word *element* is used in this section instead of property, given that *property* is not as familiar a concept across all metadata communities.) These aspects of syntax standardization are further explained below:

- *Element ordering*: Data structure standards may include element ordering recommendations or specifications, such as the author/creator element should (or must) always preceded the title element. Familiar bibliography standards, such as the American Psychological Association or the Chicago citation style have an element ordering syntax in the way bibliographies citations are constructed; and these standards integrate a grammar syntax (defined below) via prescribed punctuation. There are many data structures, such as the Dublin Core, that do not have a standardize element ordering protocol; however initiatives using such schemes may determine their own standard approach to organizing metadata elements.
- *Value structuring*: Content value standards may include value structuring requirements. For example, *LCSH* has a protocol for constructing subject heading strings [topic—period subdivision]; or [topic—geographical subdivision]. Similarly, the *Art & Architecture Thesaurus*[40] has a protocol for building faceted strings. The Library of Congress Name Authority Headings (http://authorities.loc.gov/) includes syntaxes for named entities following the *Anglo-American Cataloging Rules*.[41] For example, personal name is structured with the surname, followed by foreman (e.g., Picasso, Pablo). There are also syntax standards to help with content values that may not necessarily be taken from a controlled vocabulary. One example is the W3C Date and Time Formats,[42] a subset of ISO 8601, which recommend the syntax of YYYY-MM-DD for dates and other content syntaxes depending on available date and time information.
- *Grammar syntax*: Communication standards embody a grammar syntax for producing valid encoding. An obvious example is the way in which XML angle brackets are created with a "<" to represent the start of encoding a metadata element, and then use a "/>" to represent closure. Example 3, above, illustrates both MARC and XML encoding syntax. The core of the MARC bibliographic record includes tags (the three digit numbers), delimiters (a dollar sign: $), and delimiter codes (often lower case letters). The Dublin Core metadata record presents an example of XML grammar, with angle brackets as well as prescribed punctuation.

Standards, as reviewed here, are integral to many aspects of metadata. It is useful to keep in mind that metadata standards are discussed and labeled in many ways, and generally "a said standard" includes multiple aspects or types of standards. A case in point is the *Anglo-American Cataloging Rules*,[41] which is often labeled as a *content standard*, integrating aspects of a data structure, content syntax, and encoding syntax (the encoding follows ISBD punctuation). The most important aspect of any standard is that they enable metadata to be used more effectively supporting functions (e.g., resource discovery, management, or authentication); and, at the foundation level, standards guide metadata generation.

METADATA GENERATION

Metadata generation is the act of creating or producing metadata, and can be generated via different processes, applications, and classes of people.[43]

Metadata Generation Processes

Metadata is generated via manual, automatic, or, a combinatory approach. Manual metadata generation necessitates human engagement (e.g., metadata professionals, content creators, and technical assistants); automatic metadata generation involves the use of machine processing; and the combinatory approach integrates both manual and automatic methods.

An overview of metadata generation processes

It is nearly impossible to find an example of metadata produced entirely by manual means, given that metadata is fairly well rooted in the world of electronic and digital information. In fact, it is commonplace that metadata generation activities include some reliance on technology and programmed algorithms. For example, an application requiring manual metadata input may link to external standards and automatically generate and validate encoding. The OpenSource Metadata Framework (OMF) Template (Example 4) for Linux software and software documentation presents an example, with the last button saying "xmlify."

Automatic metadata algorithms are frequently in place recording the date the digital object was created or modified, who created the object or its metadata (depending on login information or work station accessed), and size of the object; although, authors and application users are often unaware of these algorithms. The only example of a purely manual metadata approach is the process of *handwritten* labeling, indexing, or cataloging.

Similarly to the near absence of purely automatic metadata generation, most automatic processes require some human involvement to, at the very least, initiate the operation. At minimum the human may need to point the application to a resource identifier as required with DC-dot (http://www.ukoln.ac.uk/metadata/dcdot/). Humans are frequently involved in some aspect of metadata evaluation when automatic processes are used, given known shortcomings of machine processing (e.g., limited capabilities to disambiguate among concepts).

Automatic metadata generation approaches

Recognizing that metadata generation generally involves a mix of manual and automatic methods has prompted the metadata community to pin-point areas where human engagement is essential, and where automatic processes should dominate. For example, it does not make sense for a human to manually reproduce resource identifier, such as a URL, when it could be automatically harvested from a Webpage; and the automatic approach is less prone to errors than the manual approach. As part of an effort to advance the development of metadata generation applications, the DCMI Tools Community has prepared a glossary [draft][43] defining specific types of automatic metadata generation approaches, which are further articulated here.

- *Derived metadata*: Metadata automatically generated according to system designed (pre-programmed) profiles. For example, a system program may automatically derive metadata values for "date created," "date modified," or "resource size." Profiles can be designed to automatically populate a metadata record with default values, such as "rights access," or "creator" information.
- *Metadata extraction*: Metadata generated by running automatic indexing algorithm against resource content. For example, term frequency algorithms are used to extract and determine subject keywords; and automatic detection of noun phrases may help extract values for other metadata properties, such as "author," "date," and "title." Semi-structured metadata, determined by the fairly consistent placement of metadata values (e.g., title, keywords, and author names) within document content, can also be extracted.
- *Metadata harvesting*: Metadata is automatically gathered from existing metadata sources, regardless of whether it was originally generated via automatic or manual means. Metadata can be harvested from a range of sources (e.g., a resource header, metadata registries, or database). Metadata harvesting is a key aspect of the Open Archives Initiative (OAI) (http://www.openarchives.org/), an electronic pre-print service. Extraction of semi-structured metadata from document content has an element of harvesting.

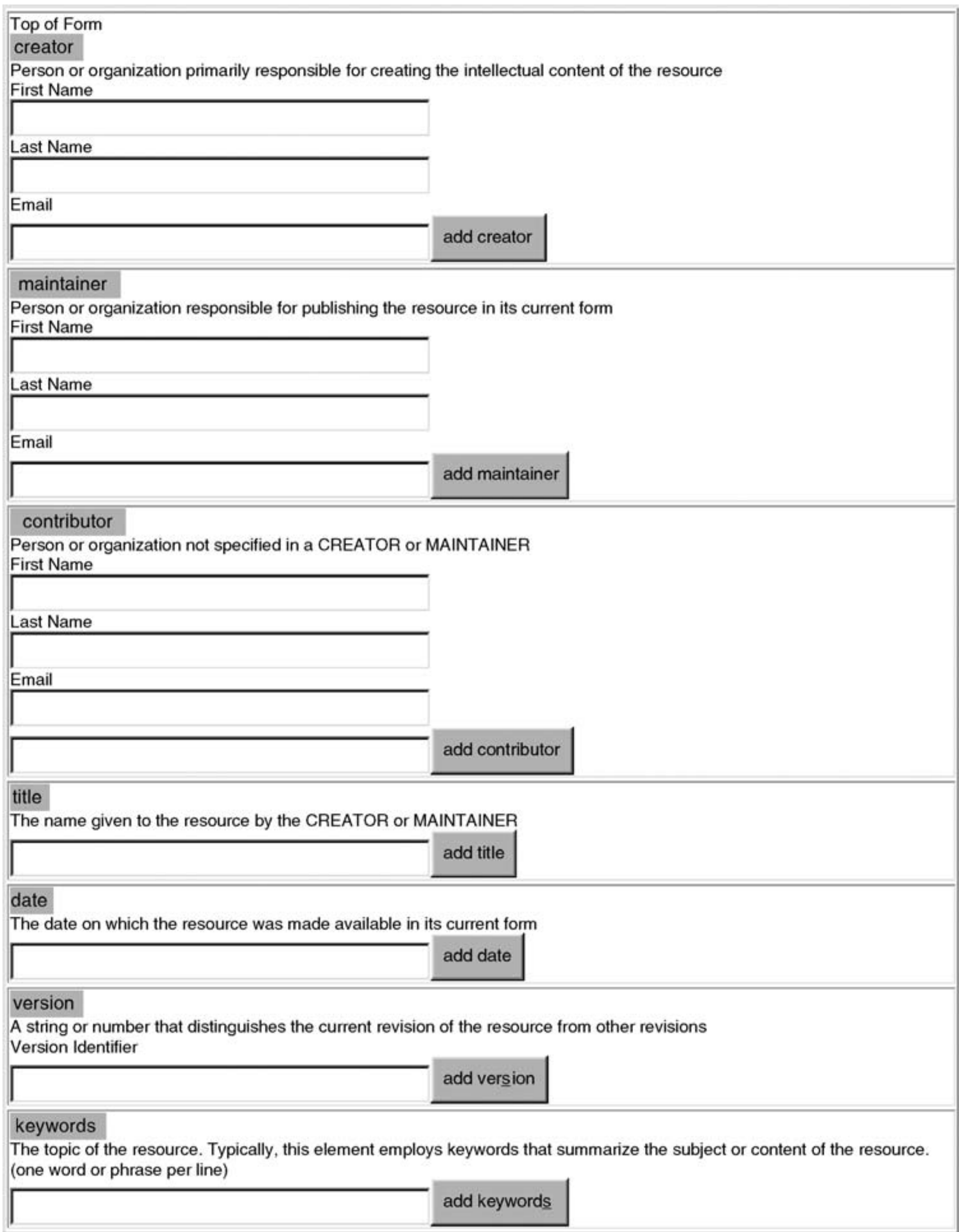
There are multiple approaches for generating metadata; and the method selected depends on a host of factors. Chief considerations include the type of objects being represented (e.g., online conference proceedings, personal photographs, a scientific data set); the environment where the metadata will be hosted (e.g., a digital library, scientific repository, or personal account on a social networking site); who is creating the metadata; available financial and human resources for the task; and the complexity of and intellectual requirements associated with the underlying schemes and standards used. All of these factors together have a direct bearing on the type of application selected for generating metadata.

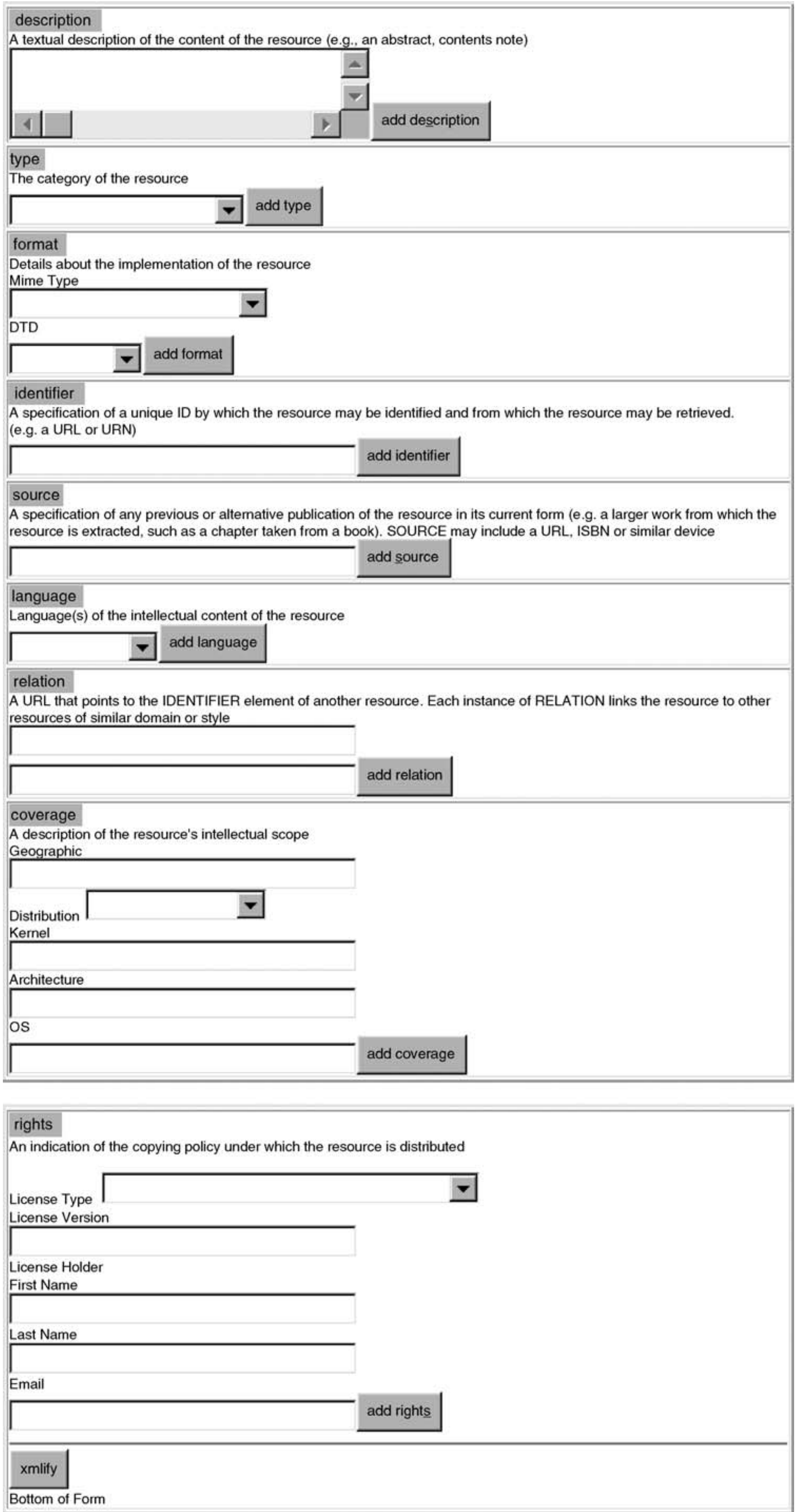
Applications

The range of applications supporting metadata is extensive. The previous *ELIS* entry covered this topic by identifying templates, editors, generators, and document editors. Although these intellectual distinctions are still applicable, these concepts are used interchangeably and inconsistently by application developers and users alike. Another way to view the range of metadata applications available is to consider the context in which they are used, including how they are marketed. Four contexts considered here include: 1) tools designated specifically as metadata applications; 2) library management systems (LMS); 3) content management systems (CMS); and 4) daily use applications.

- *Metadata applications*: The growing need for metadata has motivated the development of applications specifically labeled as metadata tools. These applications generally provide templates for manual metadata input, and permit manual editing once the metadata is generated. Many of these applications automatically link to property definitions; list acceptable content value standards or even values for selection; and automatically generate XML or other desired encoding, as illustrated with the "xmlify" button in the OMF

Example 4: OpenSource Metadata Framework (OMF) Template


Top of Form
creator
Person or organization primarily responsible for creating the intellectual content of the resource
First Name
Last Name
Email
add creator
maintainer
Person or organization responsible for publishing the resource in its current form
First Name
Last Name
Email
add maintainer
contributor
Person or organization not specified in a CREATOR or MAINTAINER
First Name
Last Name
Email
add contributor
title
The name given to the resource by the CREATOR or MAINTAINER
add title
date
The date on which the resource was made available in its current form
add date
version
A string or number that distinguishes the current revision of the resource from other revisions
Version Identifier
add version
keywords
The topic of the resource. Typically, this element employs keywords that summarize the subject or content of the resource.
(one word or phrase per line)
add keywords



description
A textual description of the content of the resource (e.g., an abstract, contents note)
add description

type
The category of the resource
add type

format
Details about the implementation of the resource
Mime Type
DTD
add format

identifier
A specification of a unique ID by which the resource may be identified and from which the resource may be retrieved.
(e.g. a URL or URN)
add identifier

source
A specification of any previous or alternative publication of the resource in its current form (e.g. a larger work from which the resource is extracted, such as a chapter taken from a book). SOURCE may include a URL, ISBN or similar device
add source

language
Language(s) of the intellectual content of the resource
add language

relation
A URL that points to the IDENTIFIER element of another resource. Each instance of RELATION links the resource to other resources of similar domain or style
add relation

coverage
A description of the resource's intellectual scope
Geographic
Distribution
Kernel
Architecture
OS
add coverage

rights
An indication of the copying policy under which the resource is distributed
License Type
License Version
License Holder
First Name
Last Name
Email
add rights

xmlify
Bottom of Form

Template (Example 4). The Berkeley Web Template CGI script for EAD finding aids (http://sunsite3.berkeley.edu/ead/tools/template/), and the hCard Creator (http://microformats.org/code/hcard/creator) for hCard Microformats Wiki 2.0 (http://microformats.org/) (a standard used to represent people, companies, organizations, and places) are examples of these more manually driven metadata applications.

There are metadata applications supporting a greater degree of automatic processing, such as DC-dot and Metatag Extractor (http://www.hooverwebdesign.com/tools/metatags.php). These applications automatically harvest metadata from the resource's source code. Additionally, DC-dot extracts resource content where harvesting proves insufficient and also includes a template for manual editing.

- *Library management systems* (LMS): As libraries have engaged in metadata generation, library software has integrated the support for metadata standards. Examples include Innovative Interfaces Inc.'s MetaData Builder (http://www.iii.com/products/metadata_builder.shtml), which supports the creation for both Dublin Core and the EAD metadata; and CONTENTdm (http://www.contentdm.com/), which supports Dublin Core, VRA Core, and newly created metadata schemes and vocabularies. There are also a number of open source LMS, such as Greenstone Digital Library Software (http://www.greenstone.org/), supporting many of the metadata functions found in commercial products.
- *Content management systems* (CMS): CMS require metadata for content management. Ektron (http://www.ektron.com/web-content-management-solutions.aspx) includes basic metadata properties such a as title, keywords, language; and this software can be programmed to assign default keywords. IBM Lotus Quickr Web (http://www.ibm.com/developerworks/lotus/library/quickr-web-services/) automatically generates date created, last modified timestamps, and identifier metadata to maintain server activities. Similar to LMS, there are many open source CMS that support metadata. Additionally, many CMS integrate taxonomy plug-ins to improve metadata quality. Synaptica® (http://www.synaptica.com/djcs/synaptica/) from Dow Jones Client Solutions is among one of the more popular plug-ins for developing and managing taxonomies.
- *Daily use software*: Although this is rather a "catch-all" category, it is the case that anyone working on any type of computer interfaces with some form of metadata generation software, whether or not they are aware of it. Examples include software people use daily to arrange information captured on their iPods, palms, cell phones, and other mobile devices. The AMeGA Report,[44] produced to address Section 4.2 of the *Library of Congress Bibliographic Control Action Plan*,[45] analyzed metadata generation features and functionalities embedded in software people use to create content daily (e.g., Microsoft Word, Adobe, Dreamweaver, and Moveable Type), and found that several metadata elements supported by these applications easily map to the Dublin Core. Finally, and perhaps the most obvious daily use applications supporting metadata generation underlie social networking activities. For example, Flickr (http://www.flickr.com/) and Delicious (http://delicious. com/) support folksonomic tagging and the generation of metadata, a good portion of which aligns with Dublin Core properties.[10]

Classes of Persons

Among the classes of persons involved in metadata generation, are professional metadata creators, technical metadata creators, content creators, and public metadata creators.

- *Professional metadata creators* include catalogers, indexers, and other individuals who have had formal education or official on-the-job training to learn about metadata standards and issues; and they generally work in libraries, archives, publishing houses, and formal information agencies. This class of persons is known as third-party metadata creators because they produce metadata for content created by other individuals. Professional metadata creators have the intellectual capacity to make sophisticated interpretative metadata-related decisions, work with classificatory systems and other complex content value systems, and have some theoretical understanding of metadata. Given expert knowledge, the professional's greatest contribution may be evaluating metadata, managing metadata generation activities, or helping to develop tools that facilitate effective and expedient metadata production.
- *Technical metadata creators* include data in-putters, paraprofessionals, and other individuals who generally have had basic training, but have not participated in a formal structured or certified educational program. Technical metadata creators are also third-party metadata creators, and generally not assigned the same degree of responsibility as a metadata professional; however, they may take on more sophisticated tasks over the duration of their work-life.
- *Content creators* are individuals creating metadata for intellectual content they have authored. There are many types of content creators—authors of text, photographers, creators of video—amateurs, professionals, and the average citizen.

Authors of scientific publications regularly engaged in metadata generation in the pre-Web environment by writing abstracts, identifying keywords, and even assigning classificatory indicators when submitting their work via peer-review channels. The online peer-review process has maintained these author metadata requirements. An example is the Association of Computing Machinery/Special Interest Group (ACM/SIG) Proceedings Templates (http://www.acm.org/sigs/publications/proceedings-templates), which require authors to select "categories and subject descriptors" from the *ACM Computing Classification Scheme*.[46]

The content creator metadata environment is thriving today via developments such as the OAI, institutional and specialized repositories (e.g., GenBank, http://www.ncbi.nlm.nih.gov/Genbank/, for gene sequences), and social networking sites, where people create metadata to share photographs (e.g., Flickr), bookmarks (e.g., Delicious), news (e.g., Blogs), and news about oneself (e.g., Facebook, http://www.facebook.com/).

- *Public metadata creators* include community or subject enthusiasts who create metadata for a resource authored by other individuals. A subcategory of public metadata creators includes *users*—people creating metadata by annotating content they have used, and sharing their insights.

During the very early years of the Web, 1995–1999, people created lists of hyperlinks for topics they were passionate about (e.g., travel, sports, cooking, pets, politics, and entertainment), resulting in personal subject gateways. These personal undertaking included basic metadata: title, creator, and sometimes an annotation. While these types of Web sites are still visible, public metadata creators have generally turned to social networking cites to share favorite Web sites, tag information, blog, or annotate information.

Public metadata creators help build collective knowledge through their efforts, and are increasingly being accommodated in reputable information systems. For example, WorldCat (http://www.worldcat.org/), a service connecting more than 10,000 libraries worldwide, has introduced a user tagging option. This service allows users to manage bibliographic records and enhance resource discovery for other WorldCat users. The Steve project (http://www.steve.museum/), a partnership between leading museums and the general public, is another important example exploring how social tagging can enhance access to museum collections and further engage visitors.[47]

Professional catalogers and metadata experts are not able to handle the sheer volume of information being generated today; and it is not feasible to ask these highly skilled and paid individuals to create metadata for every digital object, particularly when there are other individuals and applications to help with the process. It is, therefore, encouraging to see the increased functionalities in metadata application and more and more people engaging in metadata generation.

METADATA MODELS

The increase in metadata generation has encouraged the development of metadata models supporting interoperability, data reuse, and more intelligent packaging of metadata. This section reviews four key models gaining acceptance in the metadata community, although there are many additional models.

Arguably the most simplistic model impacting metadata developments is the Resource Description Framework (RDF).[48] RDF is a simple model for rendering metadata instances into simple discrete and explicit statements (Example 5). The overriding goals of RDF are to impose structure, facilitate the unambiguous and consistent expression of semantics, and support more intelligent use of Web data. RDF underlies the Web Ontology Language Overview[49] and Simple Knowledge Organization System[50]—two key specifications for developing the Semantic Web.

RDF statements are frequently referred to as *literals* or *triples*, and include a subject, predicate, and object (Example 5); these statements can be visually represented via RDF graphs (Fig. 1).

Multiple RDF statements can be made about the same object. Additionally, RDF supports an iterative process, whereby an "object" of one RDF statement could be the subject of another RDF statement. A statement illustrating iteration might say that the "subject" *Harley–Davidson motorcycle* (from *LCSH*) (which is the "object" in Figure 1), has a "predicate" *identifier* (the LC control number) with the "object" (meaning the *value*) *85058931* (see Fig. 2).

RDF was initiated as a model that does not necessarily need to be expressed in XML. However, RDF implementation is supported by series of additional specifications addressing the syntax, vocabulary, and semantics for creating RDF/XML statements that permit metadata to be shared. Conceivably, once an RDF statement is made about an object on the Web, that statement (a metadata instance)

Example 5: RDF triple

Subject	Predicate	Object
The **subject** (meaning the resource) http://www.harley-davidson.com	Has a **predicate** (a Dublin Core property) The "dc.subject"	Containing **object** (a value; and in this case an *LCSH* value) "Harley–Davidson motorcycle"

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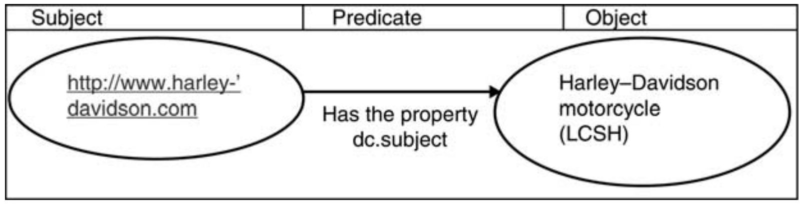

Fig. 1 RDF graphical representation for the triple in Example 5.

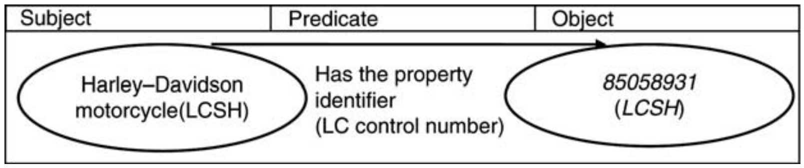

Fig. 2 RDF graphical representation for the "subject" *Harley–Davidson motorcycle* (an *LCSH* heading).

can be reused again and again, although more development is needed to truly share and reuse RDF renderings.

Another model increasingly being discussed in the metadata community is the Functional Requirement for Bibliographic Records (FRBR),[51] published by the International Federation of Library Associations and Institutions. A body of research has advanced knowledge about the bibliographic object and the notion of the *work*[52,53] in our online library catalogs. Building on these advancements, the FRBR model includes four entities: *work*, *expression*, *manifestation*, and *item*. The partitioning of bibliographic data (or metadata) following FRBR allows for data reuse; more sophisticated linking of entities; and a richer descriptive environment. The model is still heavily conceptual, although there are instances of FRBR implementations, most notably OCLC's Fiction Finder (http://fictionfinder.oclc.org/).

FRBR's foundation work predates the Web; and, yet, it is extremely applicable to the digital world, where resources are copied and modified rapidly, and the reuse of bibliographic data is an important goal. FRBR presents library users with an opportunity for gaining a greater understanding of the bibliographic universe from where they gather sources; and, in the long run, FRBR could prove extremely cost effective, not only for users making important links among resources, but by eliminating duplicative metadata efforts. These goals have inspired additional FRBR efforts relating to name and subject authority data.

The Metadata Encoding and Transmission Standard (METS)[54] is another model being used in the digital library/repository environment. METS is a framework for packaging descriptive, administrative, and structural metadata within an XML framework, and wrapping that metadata around a digital resource. As digital initiatives began to proliferate toward the end of the 1990s, the need for different types of metadata standards supporting different functions became increasingly evident. This need led to interest in developing a consistent way to package resource metadata drawing from different standards—a goal that was further motivated by the need to enable greater interoperability and reuse of the resource and its associated metadata. The Making of Amercica-2 (MOA-2) (http://sunsite.berkeley.edu/moa2/), a Digital Library Federation project, formalized these ideas and created a XML/document type definition (DTD) for packaging metadata; and these efforts progressed to form what is today METS.

METS has the following seven key sections: 1) *METS header* for describing the object; 2) *descriptive metadata* linking to external metadata (e.g., a MARC bibliographic record or a Dublin Core record, representing the object, but stored elsewhere), and internal descriptive metadata enriching external descriptions; 3) *administrative metadata* documenting creation, source, and rights information both externally and internally; 4) *file section* listing all files comprising the digital object; 5) *structural map* outlining the resource's arrangement and linking to the object's content; 6) *structural links* recording hyperlinks between sections of an object's content; and 7) *behavior* documenting and pointing to executable behaviors associated with the METS object's content, or code for initiating an operation.

The Dublin Core Abstract Model (DCAM)[55] is among the more recent metadata models. The DCAM incorporates RDF and has been developed to advance the metadata development, and to bring metadata activities more in-line with the Semantic Web initiative. Two key principles underlying DCAM are: 1) a resource can be any type of discrete entity (as discussed above in "Defining Metadata" section), and 2) metadata can be created for any object. The DCAM asserts that a metadata record can include one or more metadata statements; and a simple RDF statement is an acceptable metadata record. This approach differs from traditional notions of a bibliographic cataloging, where a metadata record includes multiple property/value pairs. The DCAM is "object centered," and the emphasis is on cataloging objects (e.g., words, numbers, discrete entities) at the most discrete level, so that the object and metadata are reusable. The majority of metadata work is resource centric—with resource referring to an entire Web site, or the types of entities collected by libraries, albeit digital (e.g., books, reports, photographs). Implementing metadata within the DCAM requires a new, more object-centered perspective for metadata. DCAM is in its infancy, but the approach may transform metadata activities to a new level.

CONCLUSION

Metadata is a dynamic topic and has evolved considerably since the initial *ELIS* metadata entry was published in 2002.[1] This current entry stands as a new article, with fresh coverage of the earlier topics (e.g., the definition of metadata and metadata generation), and greater attention to metadata models. This entry provides new facts uncovered on the history of metadata; presents an overview of different metadata types, functions, and schemes; provides a series of domain-specific definitions for metadata; and discusses the various types of standards comprising metadata architectures.

The remarkable growth in metadata activities has been extremely positive, resulting in greater access to information and better documentation. However, like many developments, this growth has not been without challenges. Determining how to generate metadata (emphasizing an automatic or manual approach), and who to involve in the process (professionals, technical assistants, content creators, the public), presents metadata quality and workflow challenges. Striving for interoperability and sharing metadata can pit local metadata needs against higher level goals. And, perhaps the most exciting challenges stem from the goal of *metadata reuse*. Those engaged in metadata activities debate if metadata should be generated for every discrete object and if a more globally linked Semantic Web is achievable. Efforts underway, such as the Dublin Core Singapore Framework[12] guiding application profile development, and the National Science Digital Library Metadata Registry (http://metadataregistry.org/), for sharing metadata schemes, provide a means for addressing several metadata reuse challenges. These efforts will, no doubt, continue to evolve through evaluation and use. And, as metadata progresses, new challenges will undoubtedly surface, and new solutions will be sought.

It is clear that metadata is an ubiquitous topic and an integral part of our digital information infrastructure. Education, the arts, science, industry, government, and the many humanistic, scientific, and social pursuits that comprise our world have rallied to develop, implement, and adhere to some form of metadata practice. There is ample evidence showing that metadata has touched nearly every discipline and societal sector coming into contact with digital information. The goals are similar across the board—to facilitate the preservation, discovery, access, and sharing of digital output. In closing, the range of metadata activities over this last decade are both extensive and astonishing, and presents an unprecedented opportunity to share information and knowledge as we move forward in this millennium.

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