

Metadata Standards for Web-Based Resources

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One of the main reasons for the Web's success is that it lets us provide information to millions of people. We can integrate information already available somewhere on the Web in our own pages by just adding a link. However, finding relevant information has become more difficult. Search engines usually offer thousands of query results if the user provides popular or generic keywords. The problem is that it's still not possible to describe HTML-page or multimedia content adequately. Data about the information in a resource, also called metadata, can allow the proper search and processing of Web pages.¹ Metadata shifts the description of the content from the string-matching level, where you can't make decisions about a resource's relevance, to a conceptual level, where users can semantically describe what they are actually looking for.

Consider the following definition of multimedia:

A multimedia system is characterized by computer-controlled, integrated production, manipulation, presentation, storage, and communication of independent information, which is encoded at least through a continuous and a discrete medium.²

This suffices from a technical point of view, and it helps people understand how to define and build a multimedia system. What's missing is how to describe what's inside a multimedia resource, what it's good for, and who can or should use it and why. We need a description of the content of multimedia resources available on the Web, tailored to specific needs of different users. The Dublin Core, a simple metadata element set for Web resources, and the Learning Object Metadata Scheme by the IEEE Working Group P1484.12 are two examples of metadata schemes that describe multimedia resources. (See the "Web Resources" sidebar for more information.)

Metadata

We can define metadata as information about information. Librarians have used it for hundreds of years. In fact, a library catalog, which helps librarians manage their books and journals, is a popular example of metadata use. Users search these catalogs for material about a particular subject and find information on the library shelves.

Search engines like Yahoo are using catalogs to structure Web page content. If there's no information available about the resource, it's impossible to classify it other than by manually reviewing it and deciding where to list it in the catalog. Having information about the content, author, or legal conditions makes it easier for humans and computers to classify a resource. Metadata can be useful for

- summarizing the meaning of the data,
- allowing users to search for the data,
- allowing users to determine if the data is what they want,
- giving information that affects the use of data (legal conditions, size, age, and so on), and
- indicating relationships with other resources.³

To use and benefit from metadata on the Internet, we need a common format for expressing it that should be designed for machines rather than humans. Merging the web of human-readable documents with a network of machine-understandable metadata promises immense potential.⁴ Proxy caches, Web browsers, search engines, and other Web tools can then work better with humans and participate more intelligently in locating, evaluating, accessing, and managing Web resources.

Metadata application and syntax

The first step in describing a resource with metadata is choosing an appropriate metadata element set and an appropriate vocabulary as values for the elements. Often the vocabulary for a metadata scheme comes from an existing ontology that describes knowledge in general—for example, the International Standard ISO/IEC 11179: Information technology, specification, and standardization of data elements.

Although we've developed every element set and scheme to find and manage resources, choosing a scheme depends on the resource's target group. For example, the type and number of metadata descriptions a librarian needs to catalog a video is completely different from those a company needs to manage a Web portal of self-learning videos, even though they might be describing the same multimedia resource. Therefore, different metadata descriptions for the same resource exist.

One simple metadata scheme—conceived for author-generated descriptions of Web resources—is the Dublin Core. (Another possible metadata scheme, especially for videos, is MPEG-7.⁵) The Dublin Core facilitates the discovery of online resources in a networked environment. The current metadata set consists of 15 elements. It's completely text oriented and, therefore, human readable. Each element is repeatable and optional, and the entire set is extensible.⁶ The 15 categories of the Dublin Core are

- title,
- author or creator,
- subject and keywords,
- description,
- publisher,
- other contributors,
- date,
- resource type,
- format,
- resource identifier,
- source,

Web Resources

ARIADNE Consortium: <http://ariadne.unil.ch>
IMS Project: <http://www.imsproject.org>
Learning Object Metadata Scheme: http://ltsc.ieee.org/doc/wg12/LOM_WD5.pdf
Learning Object Metadata Working Group: <http://ltsc.ieee.org/wg12/index.html>
LOM-Editor from KOM, TU Darmstadt: <http://www.multibook.de/lom>
LRN 2.0 Toolkit, Microsoft: <http://www.microsoft.com/elearn>

- language,
- relation,
- coverage, and
- rights management.

Depending on the element set, we can apply metadata to a resource in different ways. Metadata can be within the resource itself—for example, as digital watermarks in pictures or videos that protect a resource's integrity or ensure its authorship—as HTML metatags, or in a separate description file.

When including the metadata description within the resource, the syntax of the resource gives the syntax and encoding for the metadata. HTML metatags are a simple way to apply metadata to a Web-based document. The following example shows Dublin Core encoded at the beginning of an HTML page with metatags. In this case, the metadata describes a Java applet used for visualization of communication protocols in an Ethernet local area network.

```
<META NAME="DC.Title" CONTENT="Ethernet Applet">
<META NAME="DC.Description"
  CONTENT="Visualization of Carrier
  Sense Multiple Access Protocol with
  Collision Detection (CSMA/CD) IEEE
  802.3 (Ethernet)">
<META NAME="DC.Type" CONTENT="Learning
  Material">
<META NAME="DC.Format" CONTENT="Java
  Applet">
<META NAME="DC.Relation.References"
  CONTENT="http://www.multibook.de/et
  hernet.htm">
```

The disadvantage of this approach is that it's impossible to change parts of the metadata

RDF offers a way to publish human-readable and machine-processable vocabularies designed to encourage the reuse and extension of metadata semantics among disparate information communities.

description without accessing the resource. The other problem is duplication of information. The `DC.Title` attribute's value will most likely appear again in the HTML Title tag. Using semantic annotation languages like HTMLa to include metadata within the resource overcomes this problem, but they have other drawbacks.⁷

If we store and deliver the description separately from the resource, how do we encode the descriptions? Although almost as many possibilities for encoding metadata exist as there are metadata schemes, we can store almost every metadata scheme as an XML file. Unfortunately, using XML and a document type definition (DTD) to describe a metadata scheme only lets us check a description's syntax. We can't use them to specify what the description elements mean. One approach aimed at getting closer to the meaning of descriptions is the World Wide Web Consortium's Resource Description Framework (RDF).⁸

RDF

RDF permits encoding, exchanging, and reusing structured metadata. It provides the basic requirements for metadata interoperability across different resource description communities and applications. RDF builds on the XML syntax and imposes needed structural constraints to express semantics. Plus, it offers a way to publish human-readable and machine-processable vocabularies designed to encourage the reuse and extension of metadata semantics among disparate information communities.

RDF is based on a concrete formal model that uses directed graphs for representing the semantics of metadata. Basically, a collection of properties, or an RDF description, describes a resource. Each of these properties has a property type and value. The RDF model builds on the triple relationship of resource, property, and value—in other words, subject, predicate, and object. We can use the Ethernet applet we mentioned earlier as an example. In this model, the applet is the resource, `DC.Type` is a property of this resource, and `Learning Material` is the value of this property. The corresponding RDF-XML syntax for this example is

```
<?xml version = "1.0"?>
<rdf:RDF
  xmlns:rdf="http://www.w3.org/1999/0
2/22-rdf-syntax-ns#"xmlns:DC=
"http://metadata.net/dstc/DC-10-
EN/#">
<rdf:Description xml:lang="en" about="
http://www.multibook.de/EthernetAp-
plet.html ">
<DC:Title>Ethernet Applet</DC:Title>
<DC:Description>Visualization of
Carrier Sense Multiple Access Proto-
col with Collision Detection
(CSMA/CD) IEEE 802.3 (Ethernet)
</DC:Description>
<DC:Type>Learning Material</DC:Type>
<DC:Format>Java Applet</DC:Format>
<DC:Relation.References>http://www.mu
ltibook.de/ethernet.htm</DC:Relatio
n.References>
</rdf:Description>
</rdf:RDF>
```

RDF uses the W3C's namespace convention. In this example, we declare both the RDF and Dublin Core schemes as namespaces and abbreviate them as RDF and DC, respectively. The Uniform Resource Identifiers associated with these namespaces refer to the related schemes. Using them, we can access the necessary vocabularies for each data model. The element `<rdf:RDF>` is a wrapper that marks the boundaries in an XML document where the content is explicitly intended to be mapped into an RDF data model instance. The element `<rdf:Description>` contains the URI of the resource in its `about` statement. The element `<DC:Type>` in the context of the description represents a property-type `DC:Type` and a value of `Learning Material`.

While XML specifies a description's syntax,

RDF tries to structure the meaning of the descriptions' elements. An RDF description provides answers to questions like, what is the statement about, who says it, and where is it stored? Like XML, it also doesn't provide answers to the question, what is the meaning of the statement? To answer this question, we must agree on a shared vocabulary or namespace about the statements. Without using a vocabulary, it's impossible to automatically make decisions about the resource. Therefore, the W3C is currently developing the RDF Schema.⁹

The RDF Schema introduces a basic vocabulary for a statement's meaning in a metadata description and for the relation between two metadata descriptions. Although the vocabulary in the RDF Scheme is currently limited, it builds the bridge between metadata descriptions such as the Dublin Core and formal semantic descriptions of specific domains called ontologies. Ontologies using description languages like the Ontology Interchange Language (OIL)¹⁰—where the concepts of the ontology can be encoded with the RDF Schema—can be connected with a metadata description of a Web-based resource also encoded with the RDF Schema. The combination of semantic networks or ontologies with descriptions of Web-based resources will eventually lead to the so-called Semantic Web.¹¹

LOM

Universities and many other organizations need to manage, find, and reuse learning materials, so describing resources with appropriate metadata could be particularly useful. One of the most promising metadata approaches for describing learning resources was developed by the IEEE Working Group P1484.12: the Learning Object Metadata (LOM) Scheme. (See the sidebar "LOM's Purpose.") It's mainly influenced by the work of the Educom's Instructional Management Systems project and Alliance of Remote Instructional Authoring and Distribution Networks for Europe, or the ARIADNE Consortium. There are already editors available and companies like Microsoft have started to offer free software for it (See the "Web Resources" sidebar for more information). The LOM scheme uses almost every category of the Dublin Core and extends it with categories and attributes tailored to the needs of learners and authors searching the Web for material.

The LOM approach specifies the syntax and semantics of learning object metadata. A learning object is any entity, digital or nondigital, which can be used, reused, or referenced during technol-

LOM's Purpose

The purpose of the Learning Object Metadata specification (http://ltsi.ieee.org/doc/wg12/LOM_WD5.pdf) is to

- enable learners or instructors to search, evaluate, acquire, and use learning objects.
- enable the sharing and exchange of learning objects across any technology-supported learning system
- enable the development of learning objects in units that can be combined and decomposed in meaningful ways
- enable computer agents to automatically and dynamically compose personalized lessons for an individual learner
- complement the direct work on standards that focus on enabling multiple learning objects to work together within an open, distributed learning environment.
- enable, where desired, the documentation and recognition of the completion of existing or new learning and performance objectives associated with learning objects
- enable a strong and growing economy for learning objects that supports and sustains all forms of distribution whether for profit or not
- enable education, training and learning organizations—both government, public and private—to express educational content and performance standards in a format separate from the content
- provide researchers with standards that support the collection and sharing of comparable data concerning the applicability and effectiveness of learning objects
- define a simple yet, extensible standard for multiple domains and jurisdictions so it can be broadly adopted and applied
- support necessary security and authentication for the distribution and use of learning objects

ogy-supported learning. Examples of such applications include computer-based training systems, interactive learning environments, intelligent computer-aided instruction systems, distance learning systems, Web-based learning systems, and collaborative learning environments. Examples of learning objects include multimedia content, instructional content, instructional software, and software tools referenced during technology-supported learning. In a wider sense, learning objects could even include learning objectives,

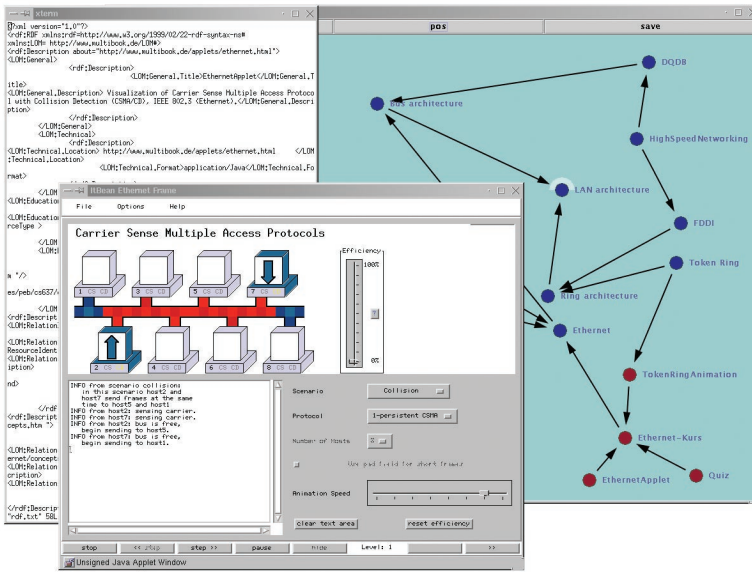


Figure 1. A modular learning resource, its Learning Object Metadata description with RDF, and a visualization of the resource including relations to other resources.

- Category 1. General, regroups all the resource’s context-independent features.
- Category 2. Lifecycle, regroups the features linked to the resource’s lifecycle.
- Category 3. Meta-metadata, regroups the features of the description itself (rather than those of the resource being described).
- Category 4. Technical, regroups the resource’s technical features.
- Category 5. Educational, regroups the resource’s educational and pedagogic features.
- Category 6. Rights, regroups the resource’s conditions of use.
- Category 7. Relation, regroups features of the resource that link it to other resources.
- Category 8. Annotation, allows for comments on the educational use of the resource.
- Category 9. Classifications, allows for description of the resource’s characteristic by entries in classifications

people, organizations, or events. The IEEE LOM standard should conform to, integrate with, or reference open standards and existing work in related areas.

The definition of LOM divides the descriptors of a learning object into categories. The version of this proposal issued on 11 November 2000 (<http://ltsc.ieee.org/wg12/index.html>) introduces nine categories:

Taken together, these categories form the Base Scheme. For example, Figures 1 through 4 show the detailed structure of the technical and educational categories. Some elements like the Descrip-

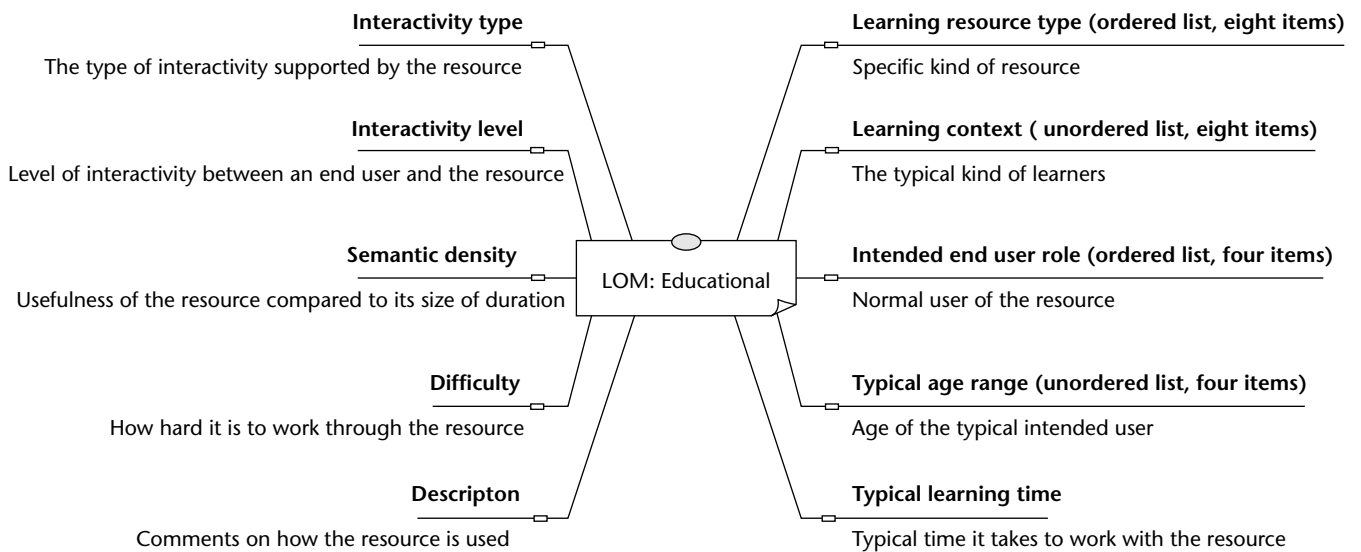


Figure 2. Educational category of the Learning Object Metadata scheme.

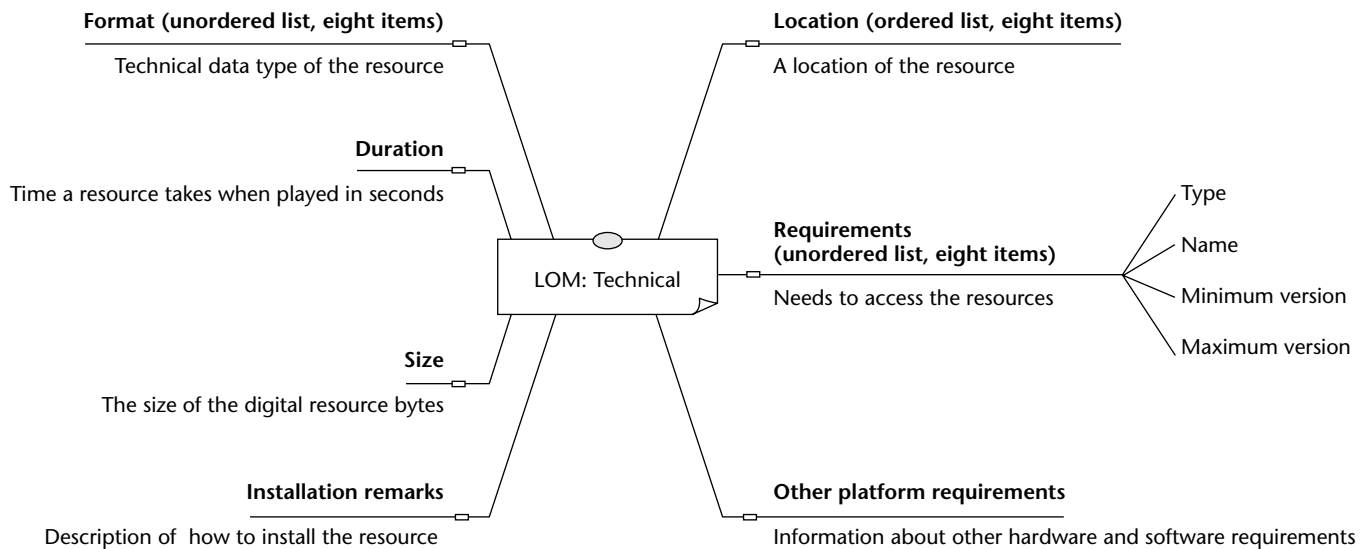


Figure 3. Technical category of the Learning Object Metadata scheme.

tion element of the General category allow free text as values, while for other elements the values are restricted to a limited vocabulary.

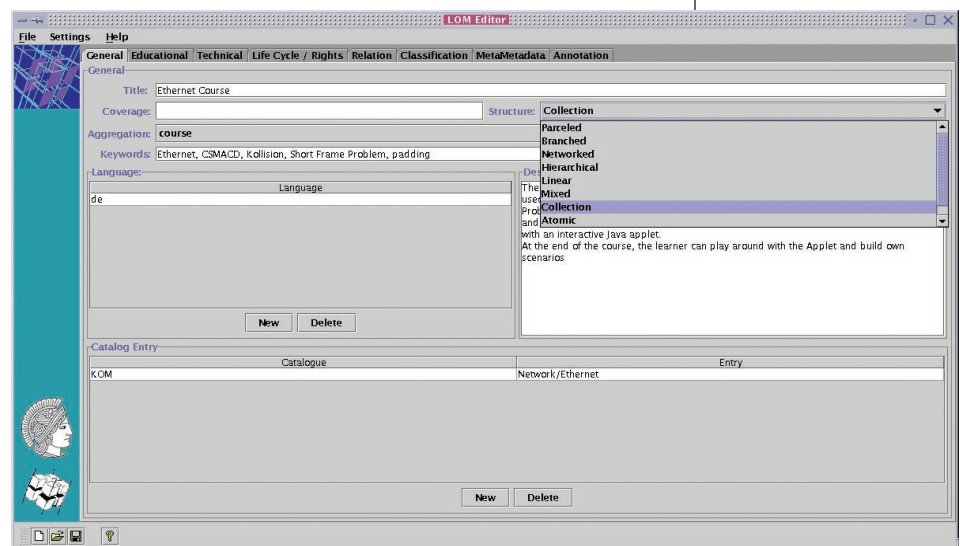
Like the Dublin Core, all categories are optional in the LOM scheme. If we want to use all categories and attributes from LOM, we must fill out at least 60 fields. An authoring system can automatically fill in entries such as author, creation date, and keywords, but there are still many entries left that users must fill in. Many people consider the time needed to describe all a resource's properties will prevent a metadata scheme from being widely distributed and used.

Another problem with using a general scheme like LOM are special attributes—for example, the difficulty level (category 5, educational) should be an integer between 0 and 4. It seems almost impossible to find a value for difficulty that's valid in diverse societies and institutions all over the world, even if you can specify a target group with the values of other attributes. Furthermore, a resource's difficulty level depends on the existing knowledge of the user and the context in which the resource is used.

It's unlikely that a single LOM description will be able to make statements about a complex educational resource. Using modular learning resources to build individual lessons automatically requires more information than the descrip-

tion of a single resource can provide. Categories with no educational background also have this problem, and the rights management category doesn't provide enough information to manage a resource within a commercial scenario. LOM tries to reduce the needs from all areas of computer-supported learning to a common denominator. It can't and it isn't meant to provide all information for every scenario. All categories are optional, and users can easily extend the Base Scheme to fit particular needs. LOM is just the common starting point of a growing user community including companies and scientific projects, to share and reuse their existing learning materials and knowledge.

Figure 4. Screen shot of an editor for describing and managing Learning Object Metadata descriptions.



Conclusion

One problem with all metadata approaches is that they try to be specialized and generic, so they are useful for different scenarios. While the languages for encoding and exchanging the metadata are already available, it will take more time for the industry to agree on a shared vocabulary for the metadata elements and values.

Another problem with metadata is supporting all the different user roles that are involved during a resource's production and distribution. Future authoring systems will be able to automatically generate many metadata values and will offer user-friendly ways to provide information without dealing with the encoded metadata directly. Future work in this area will focus on building semantic networks out of single metadata descriptions. Even for the authors of a resource, it is not always easy to provide the adequate information. Establishing a network of resources without being an expert in knowledge building is even harder without appropriate tools that hide the complexity of the underlying models. **MM**

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