LEARNING OBJECT METADATA GENERATION
IN THE WEB 2.0 ERA

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ABSTRACT
When introducing the metadata standard LOM, objectives such as the ability to find or to reuse learning objects were followed. These objectives are actually achieved in LOM only to a limited degree, despite the designation as de-facto standard for description of electronic learning content: Based on the complexity of the standard a high theoretical potential faces rejection in practice. One reason for this is that the process of metadata generation - for example, who creates which metadata attributes - is not defined in detail yet. This paper illustrates an approach which guarantees a high quantity as well as a high quality of learning object metadata records bringing together known ways of metadata creation and the new paradigm of users describing content as implemented in recent Web 2.0 applications. In the context of a concrete e-learning platform we exemplarily define who creates which metadata records of LOM in which way at what time.

KEYWORDS
learning objects, metadata generation, LOM, repositories, Web 2.0

1. INTRODUCTION
Electronic Learning, in particular in the form of Blended Learning, is applied by a rapidly increasing number of universities and companies. Realizing the concept of learning objects (Wiley, 2002) the ability to find and reuse content is generally based on the use of metadata. Due to its wide dissemination IEEE LOM (http://ltsc.ieee.org/wg12/20020612-Final-LOM-Draft.html) can be considered as de-facto standard: With more than 40 attributes, subdivided into 9 main categories, a broad description of learning objects is enabled. Metadata is collected and stored in a central place, making content available for potential users. In this way transparency of existing e-learning content and its integration within varying context is enabled (Dahl and Vossen, 2007).

While the great number of attributes enables a detailed description of learning objects, in practice a comprehensive usage of these is rare. Studies show that common attributes like title or format are filled quite often, while fields like difficulty or structure of learning object receive only little attention (Friesen, 2004). As long as metadata is only used in a single context respectively in a single system, a reduction of the attribute amount might even be reasonable, as the focus can be set regarding the specific end user (Dahl, Vossen and Westerkamp, 2006); by doing so, complexity is decreased and usability increased. Problems arise if repositories communicate and interact with each other, for example when querying distributed e-learning catalogues: While on the one side metadata records might be considered as crucial and obligatory, the same attributes might never be used on the other side as they are only optional. With a small intersection of filled
metadata records the primary objectives like finding and reusing learning objects become impossible to achievable. Furthermore, if metadata is created the way it is mostly today a high risk for superficial records arises when a single person tries to fill as many metadata fields as possible: In result a high quantity might face a low quality. In order to enable cross-system finding and cross-system reusability of learning objects, a high quantity along with a high quality of metadata must be guaranteed, which actually seldom is the case.

Thus, the core dilemma of learning object metadata creation is derived from the discrepancy between the high potential of LOM in theory and the rare implementation and usage of the complexity in practice. We put this down to the aspect that a crucial question is not answered yet:

*Who* creates *when* which *metadata records* in *which way?*

Though it is obvious that a single person is not predestinated to fill all metadata records (e.g., presented in some kind of list with empty text fields) this approach often can be found in practice. We rather see different sources interacting within the process of metadata generation. In order to be able to find and reuse, it has to be defined in detail which records are generated by whom at which time and in which way. Only in this way a high quantity along with a high quality of metadata can be achieved.

With the objective to define the process of learning object metadata generation for a concrete learning context at a university, the remainder of this paper is structured as followed: In Section 2 we examine in which way metadata for learning objects can actually be created. Furthermore the Web 2.0 tagging approach introducing the user of a system as metadata creator within a community is analyzed. Section 3 brings together the different ways of metadata creation in a single model and draws first conclusions regarding actors within the process of learning object metadata creation (answering *who?*). Section 4 disengages the well known structure of LOM consisting of 9 main categories and shows a view founded on a more classical metadata perspective. This view, breaking up the original LOM hierarchy, reveals groups of metadata records that might be generated together in the same way (answering *which metadata records?*). Section 5 describes in a real world scenario the use of a learner-centered e-learning platform; it is shown where metadata is created before and during the usage of learning objects (answering *when? / in which way?*). Section 6 summarizes the paper and outlines future work and research.

## 2. RELATED WORK

Learning object metadata can be created in many ways, each of which has its individual advantages and disadvantages. Two different approaches can primarily be identified: Following a top down approach, metadata records are filled purposefully and explicitly, while following a bottom up approach information that was collected over time is analyzed and processed in order to gain relevant metadata. In the following some top down approaches as well as one bottom up approach will be discussed.

It is obvious to delegate the task of metadata creation to an expert of the respective learning context, for example the author of a learning object or another explicitly selected person. In order to simplify the process of metadata creation so called LOM editors, which represent the standards hierarchical model for example in a tree view (Cebecci and Erdogan, 2006), can be used. Filling text fields and selecting drop down lists step by step the full complexity of LOM can be enabled. Some editors support template creation, storing attributes that are used quite often. As mentioned before one notable disadvantage of this approach is founded on the amount and complexity of LOM: If only for reasons of time and costs it is nearly impossible for a single person to create high-quantitative as well as high-qualitative metadata for a set of learning objects. A collaborative approach of metadata creation is usually neither defined nor explicitly supported.

Another approach is using computer support to a much higher degree: Automatic metadata generation extracts relevant information from learning objects and the context they are stored or used in (Cardinaels, Meire and Duval, 2005). While on the one side costs for staff and effort are reduced on the other side imprecise up to erroneous metadata records have to be taken into account. For example, as the generation of usable metadata from text-based learning objects is relatively reliable this is usually not the case when analyzing multimedia content. Even extracting the title of a Power Point Slide is an enormous challenge (as long as the title is not already set explicitly within the slides’ metadata). Concluding automatic metadata generation can be designated as a promising way that should not be used exclusively without human interaction because of a certain degree of error-proneness.
Hybrid Systems strike a balance between the ways of automatic and human metadata generation (Motolet and Baloian, 2006). Based on an automatic analysis of a learning object three groups of information can be build: Very probable values, probable values and restrictions of possible values. While the first group, including the format or the size of a learning object, usually does not require a human revision the second groups’ values are not that reliable and need to be verified. The third group consists of restrictions not suggesting concrete metadata records but reducing the scale of possible values. The approach using Hybrid Systems simplifies the process of metadata generation for persons like authors or experts integrating aspects of automatic analysis techniques. However, a detailed answer for the crucial question posed in the introduction as well as a collaborative approach is still missing.

A collaborative way of human metadata generation was introduced by Or-Bach in 2005: Following the pedagogical objective of learning content reflexion students are the ones to create learning object metadata. To give an example, programming units are annotated and described which results in an abstraction and recognition of high level concepts as smaller units, concrete examples and exercises are brought into relation. Rethinking and reinterpreting learning objects within the process of metadata generation a learning progress is achieved. This approach is the first one among activating users of a system as metadata creators. However it is not the main objective to generate preferably complete and high-quality metadata sets in the sense of e-learning repositories (ability to find, reusability). For example the idea to combine user-driven metadata generation and the expert knowledge of teachers is not pointed out and it does not become clear how collaboration at this level might look like.

The challenge of making multimedia-based content searchable is also a relevant topic independently of the learning context: For example, how can photos be labelled in order to discover them more easily? Within the scope of the recent Web 2.0 phenomenon (O'Reilly, 2005) social tagging of content emerged as a promising new way for discovery and categorization. The creators of metadata are longer experts or authors. Instead, the creation of metadata is done by system users (Mathes, 2004), who might primarily see individual reasons like an easy discovery of personally interesting photos. Based on personal metadata, interesting information for an entire community can be collected, provided the metadata of many users is brought together. Thus under certain conditions the user of a system acts as a metadata creator without being explicitly aware of his role. While in a collaborative way of metadata creation as mentioned before when students describe learning objects metadata records are filled purposefully, users of a Web 2.0 tagging application primary see personal advantages in their acting. It must be pointed out that in this case the source of metadata is not necessarily an expert of a domain wherefore a high quality of metadata is not guaranteed.

To conclude, different ways of metadata creation characterized by individual advantages and disadvantages have been discussed. In our opinion the bottom up approach as it can be found in Web 2.0 has a high potential for the context of electronic learning and the creation of learning object metadata. As this potential has not been analysed, our objective is a combination with the top down approaches mentioned before in order to accentuate the advantages and to attenuate the disadvantages.

3. SOURCES OF LEARNING OBJECT METADATA

In Section 2 approaches from different scenarios of metadata generation have been introduced. In Figure 1 these are brought together into a comprehensive model. At the first level a classical subdivision into automated and human metadata creation is made (for example cf. Gill, Gilliani-Swetland and Baca, 1998). Additionally Hybrid Systems as introduced before mediate between the two main categories.

Following Cardinalts, Meire and Duval, automatic metadata generation is broken down into 4 aspects: content analysis, context analysis, usage analysis and structure analysis. While in a content analysis information is extracted from the learning object itself (for example language, size), a context analysis involves the environment the object is currently used in. This way relevant information from user or course profiles can be gathered for metadata creation. A usage analysis for example evaluates how often a learning object was viewed by users or how long it took a learner to solve a special exercise. Conclusions regarding special metadata records can be drawn. A structure analysis involves relationship amongst objects: For example course metadata might contain relevant and applicable records for its single learning units.

Human metadata creation firstly can be subdivided into experts, mostly professional metadata creators, and authors (Greenberg et al, 2001). While experts, known from libraries, for example, are predestinated for
a categorization of content, authors create abstracts or lists of keywords. Additionally one more human metadata creator can be identified: the user of a system. In Section 2 students creating metadata records with a pedagogical objective have been mentioned. A collaborative, explicit approach has been identified. On the other hand user-driven generation as to be found in Web 2.0 tagging applications is characterized by users annotating content of their own accord with primary individual reasons. Bringing together all community metadata interesting information can be gathered. In this way of metadata creation is denoted as community-driven.

![Figure 1. Ways of learning object metadata creation.](image)

Which of these ways are interesting in combination for the challenge to describe learning objects? First of all combining automatic and human approaches seems to be reasonable. Regarding the quality of metadata Lux, Klieber and Granitzer differentiate manually generated high level metadata and automatically generated low level metadata. The fuzzy border between these two is known as the semantic gap; to bridge this gap an enormous effort has to be made if human interaction is excluded. This view, confirmed by practical problems as mentioned in Section 2, justifies a combination of automatic and human metadata creation. All four automatic analysis techniques can be used to gain information from learning objects. Referring human metadata creation the role of an expert ought to be discussed within the learning context. While in a library this job might be explicitly filled by a person who is trained to categorize content, at a university to a high probability this is not the case. However at a university due to his expert knowledge a teacher can fill this role. As the teacher is normally also the author respectively the person in charge for a learning object the two roles merge in this context. More than that, he or she is also kind of an observer, conducting the learning process and enriching the learning object with additional information whenever this is required. Users of a learning object can be denoted as learners; this might be students as well as lecturers doing further studies. The collaborative approach introduced before is rather a special case: Especially the aspect of motivation for users to create metadata is missing here as long as there is no external pressure. As will be shown later, this is not the case when following the community-driven approach.

4. ANALYSING LOM FROM A CLASSICAL METADATA PERSPECTIVE

After having considered which ways of metadata generation are relevant in the context of electronic learning, the question arises of what an assignment of concrete metadata attributes might look like. Breaking up the hierarchical model with its nine subcategories a new view on LOM, based on a classical metadata perspective, gives a first impression on groups of metadata that should be generated in the same way.

In 2001 Greenberg has analysed common metadata standards for digital objects, concerning a subdivision of their attributes into different metadata classes. Amongst others Dublin Core (DC), which is much more general than LOM as it allows a description of any digital objects, was examined. As in practice also learning objects are annotated with DC it is obvious to adopt the applied classification schema for LOM, too. In doing so we have categorized the single LOM attributes into four subclasses:

**Discovery Metadata** includes all attributes that support the ability to find learning objects. For the purpose of restriction – as LOM is a descriptive standard mostly all attributes more or less help to find an learning object - only attributes are denoted as Discovery Metadata if they enable finding an object for themselves, thus without being combined with other attributes. Accordingly the records title or keywords are included, while the format, which might be helpful in combination with the first ones but regarded as a single
entry does not enable a purposeful search, is not listed. Use Metadata contains all attributes that are meaningful while a learning object is used. This includes technical information like format or system requirements as well as intellectual characteristics as property rights or restrictions regarding the usage. Authentication Metadata involves attributes that guarantee the integrity and the overall trustfulness of a learning object. Attributes like the source of a learning object, its version or the relation to other objects are grouped here. Administration Metadata includes attributes supporting the management of a learning object as information about ownership or all meta-metadata (e.g. who created the metadata records).

In order to achieve a finer subdivision additionally each of the four metadata classes is split up into Objective and Subjective Metadata (Duval et al., 2002). Speaking of Objective Metadata involves facts as the date of creation or the current version number. Subjective Metadata may vary depending on the person who is annotating. Examples are abstracts, summaries or keyword lists. Accordingly we assign the LOM attributes a total of 8 categories. Analysed are all 45 records of LOM level two, which means all attributes below the nine main categories. Each of these is assigned to a minimum of one and a maximum of four categories; classifying a single record subjective and objective at the same time is excluded.

Table 1. LOM from a classical metadata perspective.

<table>
<thead>
<tr>
<th>Objective</th>
<th>Use</th>
<th>Authentication</th>
<th>Administration</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Id</td>
<td>General Coverage</td>
<td>Rights/Copyright</td>
<td>Lifecycle Status</td>
</tr>
<tr>
<td>General Identifier</td>
<td>Rights:Costs</td>
<td>Rights:Description</td>
<td>Lifecycle:Contribute</td>
</tr>
<tr>
<td>General:Type</td>
<td>Edu:InterType</td>
<td>Edu:InterLevel</td>
<td>Edu:Conf</td>
</tr>
<tr>
<td>Edu:FreeType</td>
<td>Technical Duration</td>
<td>Technical:Location</td>
<td>Edu:Level</td>
</tr>
<tr>
<td>Edu:Language</td>
<td>Technical:Size</td>
<td>Metadata:Description</td>
<td>Edu:Tag</td>
</tr>
<tr>
<td>Edu:Description</td>
<td>Technical:Size</td>
<td>Technical:Description</td>
<td>Edu:Title</td>
</tr>
<tr>
<td>Edu:Keywords</td>
<td>Technical:Size</td>
<td>General:Structure</td>
<td>Edu:Title</td>
</tr>
<tr>
<td>Edu:Purpose</td>
<td>Technical:Description</td>
<td>General:Structure</td>
<td>Edu:Title</td>
</tr>
<tr>
<td>Edu:Resource</td>
<td>Relation:Kind</td>
<td>Relation:Description</td>
<td>Edu:Title</td>
</tr>
</tbody>
</table>

Table 1 illustrates the assignment of the single LOM attributes. The classification is based on different sources (like Greenberg) and explicit proposals (e.g. made by Duval or Cardinaels) on the one hand and a detailed analysis accomplished by the authors on the other. Discussing each record would go far beyond the scope of this paper; it should be mentioned that the figure only shows one - as we think quite reasonable - possibility of an assignment.

Referring back to the ways of metadata generation identified as relevant in Section 3, groups of attributes can be assigned. Objective Discovery Metadata is predestined for creation by a teacher as the values are unambiguous (for example the title or the coverage of a learning object). By contrast Subjective Discovery Metadata involves individual records: Depending on the annotating person the structure of a hierarchy or the listed keywords may vary. Accordingly these attributes should be generated by learners in order to get an impression of the system users’ language. The group of Use Metadata seems suitable for automatic generation. While Objective Use Metadata typically can be generated by content, context and structure analysis for Subjective Use Metadata usage analysis seems to be applicable. Objective Authentication respectively Administration Metadata partially can be generated automatically with a high degree of correctness (for example metametadata records); however, partially an interaction with a teacher is absolutely necessary. In a semi automated approach costs of a learning object or copyrights can be proposed analysing related objects (for example examining releases of the same author or hierarchically higher respectively lower structured content). The metadata attribute describing the relationship can also be filled this way. Completing Subjective Authentication metadata as well as Subjective Discovery Metadata again seems to be predestined for a creation by learners. A concluding appraisal in either case should be the job of a teacher as only he or she has expert knowledge in the respective domain.

5. METADATA GENERATION IN A REAL WORLD SCENARIO

The conclusions obtained above are now brought together in a real world scenario. The e-learning platform learnr (http://dbms.uni-muenster.de/teaching), under development at the University of Muenster in Germany, not only gives learners a central point of access for actual learning objects, but also enables online annotation of content as known from Web 2.0. Especially activities experienced in the real world during intensive
Learning activities (for example prior to exams) are virtually supported. For example, learners can arrange digital post-its, tag content with keywords for the purpose of categorization and retrieving, build relationships amongst learning objects, or create summaries and file cards for recapitulation of important aspects.

Figure 2 illustrates the combination of top down and bottom up approaches in the context of an e-learning platform. Initially specified metadata is declared by a teacher using a LOM editor that is reduced to a relevant amount of metadata attributes (for example like share.loc: http://shareloc.uni-muenster.de). Setting up the learning object in the context of the platform, content, context and structure analysis deliver a remarkable amount of attributes automatically.

Figure 2. Metadata generation process in the context of an e-Learning platform.

Entering the phase of learning objects usage on one side algorithms can analyse the usage behaviour and generate metadata automatically, on the other side users individually begin to work with the content that is offered: Analogous to Flickr (http://www.flickr.com) tags are set to categorize objects. Structures are defined just like in RawSugar (http://www.rawsugar.com) bringing tags into relation. Well known from Delicious (http://www.del.icio.us) references can be defined, including internal as well as external resources. Digital post-its, as found on the MyStickies-webpage (http://www.mystickies.com), can be used to annotate or to create summaries. In consequence of all these activities following the bottom up approach a comprehensive amount of potential metadata accumulates. In the following the e-learning platform collects and preprocesses all accumulated metadata. Thus first of all data produced by learners is analysed and selected using data mining techniques (first filter). Then relevant information is presented to the teacher in a dialog (along with the already automatically generated metadata). The teacher finally decides which data is relevant enough to become representative learning object metadata (second filter). By and by based on automatic analysis
(context, usage) as well as activities by learners more relevant information accumulates; in consequence, the preprocessing of data by the platform and the selection by the teacher is not a single task. Rather it is a periodic, iterative process. An applicable timeframe in the context of a university could be a semester for example; from the beginning to the end quality of metadata will increase as more and higher quality data will be gathered.

Table 2. Defining the creation of learning object metadata.

<table>
<thead>
<tr>
<th>Who</th>
<th>When</th>
<th>How</th>
<th>LOM-Attributes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher</td>
<td>initial</td>
<td>LOM-Editor</td>
<td>General Title, LOM-Editor, Lifecycle, Rights, Life Exp</td>
</tr>
<tr>
<td>Platform</td>
<td>initial</td>
<td>Structure-Analysis</td>
<td>Relation Kind, Educational Description</td>
</tr>
<tr>
<td>Content-Analysis</td>
<td>initial</td>
<td>Content-Analysis</td>
<td>General Language, Educational Description</td>
</tr>
<tr>
<td>Learners</td>
<td>use</td>
<td>Content-Analysis</td>
<td>General Identifier, Metadata</td>
</tr>
<tr>
<td>Platform</td>
<td>use</td>
<td>Content-Analysis</td>
<td>Annotation Entity, Annotation Date</td>
</tr>
</tbody>
</table>

Summarizing our findings we can explicitly answer the crucial questions of metadata generation (Table 2). Initially the expert of the domain, the teacher (cf. Objective Discovery Metadata in Table 1), uses a LOM editor reduced to a relevant number of attributes to fill the records concerning the title and the coverage of a learning object. Likewise the records creator, version and status are set. In the scenario described above the educational description reflects the idea of blended learning (accompanying lectures), a variation would be a consequence of using self-assessment units in distance learning for example. Metadata attributes describing rights aspects are also filled by the teacher.

At this stage the platform already supports the teacher (cf. Objective Use Metadata in Table 1). Performing structural analysis, learning objects that are similarly structured or derived from the same author can be identified. Accordingly, the LOM editor makes proposals based on this information (Rights:Costs, Educational:Description). The educational description, for example, should be identical to a high degree concerning a course and its single units. At the same time the learning objects’ relationship to already existing learning units can be specified (for example isPartOf-relationship). Content analysis primarily delivers technical information like the format or the size of a learning object. Also the language used, the resource type (e.g. slide, exam), the interactivity type (active, expositive) and the interactivity level will be identified with a high probability. Performing context analysis an unambiguous identifier is generated and information based on user profiles is extracted; for example, conclusions regarding publishing person and timestamp, educational context or meta-metadata in general are drawn. As already mentioned, learners are annotating learning objects (cf. Subjective Discovery Metadata in Table 1). Based on tags keyword lists can be deduced, bookmarks to internal (other learning objects) or external (e.g., Wikipedia) resources deliver relationships, and notes on virtual post-its can be stored as LOM-annotations. Using appropriate algorithms and bringing together individual tag hierarchies a classification going far beyond flat folksonomy namespaces can be inferred. The general description of a learning object can also be created processing user generated metadata (analysing summaries). While the learning object is used context analysis delivers information about annotation creators (profile analysis) and corresponding timestamps. A usage analysis involving user profiles enables conclusions regarding end-user role (teacher, learner), age range or learning time: how long did it take until learners marked a learning object as “understood” in order to assign a lower priority concerning the future learning process (cf. Subjective Use Metadata in Table 1).
6. CONCLUSIONS

In this paper an integrated way of metadata creation in a real world scenario has been introduced. Answering the crucial question of *Who creates when which metadata records in which way*, high quantity as well as high quality of metadata can be achieved. Breaking up the classical LOM hierarchy with its nine main categories a subdivision of the single attributes into classical metadata classes is performed; first conclusions regarding groupings of metadata records are drawn. A real world scenario illustrates practical impact in a learner-centered e-learning platform. The teacher assures the quality deciding which data finally becomes representative learning object metadata.

Future work will focus on implementing the model presented in this paper in detail following current software architecture paradigms. For example, automatic content analysis can be loosely coupled via Web services. Also, algorithms preprocessing learner generated metadata will be improved. Additionally it has to be seen, whether all learner metadata can be stored in LOM or if the standard needs to be expanded as a result of the large variety of data. Another question addresses the number of “parallel” LOM data sets for one and the same learning object: Besides one representative metadata set additionally some kind of personalized LOM for each learner could store metadata generated by the specified user. This data set based on tags, note summaries etc. would enable an enormous degree of the (individual) ability to find. Another research question examines the ability to find and retrieve as well as reusability of learning objects from external systems and applications: the high-quality and high-quantity metadata could be “harvested” exporting all data sets into an external repository with adequate interfaces. On the other side the e-learning platform itself could offer interfaces, e.g., based on SQI (Simple Query Interface) in order to enable communication with other (meta) repositories. In this way dynamic and on-demand search for relevant learning content will be possible.

REFERENCES


Wiley, D.A., 2002. The Instructional Use of Learning Objects. *Agency for Instructional Technology*