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Lifecycle Information Management and Utilization in an Authoring by Aggregation Environment

Abstract: During their lifecycle, learning resources gather many kinds of information and relations, which could be helpful for their use, re-use and management. Unfortunately the storing, capturing and utilization of these relations is not yet supported by most of the systems involved in a learning resource's lifecycle. Especially in an authoring by aggregation environment the capturing of this lifecycle information is an intuitive task to do. In this paper we present our approach in collecting, managing and using lifecycle information in the authoring by aggregation environment ResourceCenter.

1 Introduction

During their lifecycle, learning resources gather many kinds of information and build up relations to other existing learning resources. If this lifecycle information is captured and managed, it can be utilized to add valuable functionalities for the users of the different systems. Unfortunately most of the systems involved in the lifecycle of a learning resource do not collect and preserve lifecycle information and even if they do, the information gets lost on system boundaries. In the ResourceCenter, an authoring tool, especially suited for authoring by aggregation, is combined with a repository for the provision and storage of learning resources in a web-based scenario. Such it encompasses two of the systems named before. Therefore it is a good starting point, to gather lifecycle information generated within the ResourceCenter, especially during the authoring by aggregation processes, and utilize them to provide additional information and functionalities to the authors. In chapter 2 our definition of the lifecycle of learning resources is described. In chapter 3, an overview of the lifecycle information we define is given. Chapter 4 describes the ResourceCenter in short and details on the capturing and utilization of the named lifecycle information in the ResourceCenter, while chapter 5 concentrates on related work chapter 6 concludes and gives an outlook on further steps.

2 The Lifecycle of Learning Resources

In our definition of the lifecycle of learning resources (XXXXX et al.), four different stages, like depicted in figure 1 are involved. During the *authoring* phase, the learning resources are created either completely from scratch in a dedicated authoring tool, or composed from partly existing learning resources in an authoring by aggregation tool like the ResourceCenter. During the *provision* phase, the learning resources are made available to users. In a commercial scenario this might a marketplace, or an open learning object repository in usual educational scenarios. In the *learning* phase the resources are actually used by tutors and learners, mostly in learning management systems. It is a known fact, that learning resources should be reused for them to be economically efficient. But very often it is the case that existing learning resources do not exactly match the purpose they should be used in. Therefore they have to be re-purposed and adapted to the new context of use. This is done in the re-authoring phase. When the re-authoring is done, the new learning resources can be brought back to the classical lifecycle by putting it into the repository or the marketplace again.

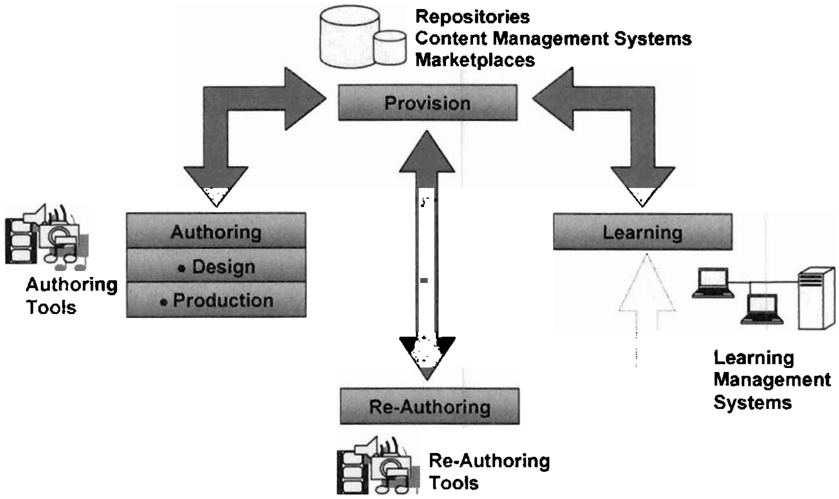


Figure 1: The Lifecycle of Learning Resources

3 Lifecycle Information

We categorize different kinds of lifecycle information depending on the systems and phases of the lifecycle of learning resources they are generated in. *Context* related lifecycle information is implicitly generated, when a learning resource is passing through its lifecycle. It mainly occurs during the provision and the learning phase. For the provision phase, examples for this kind of information can be the number of views or purchases of a learning resource in a marketplace or how often it was downloaded from a repository, respectively. During the learning phase, generated context information could be the number of times a resource has been viewed by learners in the learning management system, the duration the learners took for a learning resource or the percentage of learners who passed a test after learning a certain learning resource. In contrast to that, *relation* information is explicitly generated. It results from certain deterministic actions authors perform during the authoring or re-authoring phase. Generally we distinguish the relations given in the following table:

Table 1: Relation Information

Type of Relation	**Used Vocabulary**
aggregation	hasPart / isPartOf
sequence	isPredecessorOf / isSuccessorOf
permutation	isPermutationOf
reduction/extension	isReductionOf / isExtensionOf
requirement	requires / isRequiredBy
version	hasVersion / isVersionOf
variant	hasVariant / isVariantOf

Aggregation, sequence, permutation, reduction and requirement relations are the relations that are generated most often in the ResourceCenter, therefore it makes sense to use a separate vocabulary for these. To express relations resulting from special and therefore less often occurring adaptations or kinds of relations, that can not be mapped on specific actions performed by an author, we use the *variant* relationship.

4 Lifecycle Information in the ResourceCenter

4.1 The ResourceCenter

The ResourceCenter (Hoermann et al.) is a combination of authoring tool and repository and is designed to support authoring by aggregation. In addition to that, basic re-authoring processes like updates or corrections and manual adaptations of learning resources are possible and desired as well. The metadata wizard supports the authors in generating valid and processable metadata. The separation of layout and content provides for a high grade of reusability and simplicity for the authors of web based e-learning content. In the course structure editor, the hierarchical structure of the WBT is defined. A *course* is the highest possible aggregation of learning resources in the ResourceCenter. It consists of an arbitrary number of *sections*, which may in turn contain sections themselves. The contents of a section are defined in the section content editor. Here, media resources like images, animations or tables and the screen text for the section can be added. Meanwhile it is possible to create QTI questions in an integrated question editor and to define dynamic learning paths through the hierarchical course structure. Because of the fact, that the ResourceCenter is a combination of various components it resides in the authoring, the provision as well as the re-authoring phase of the lifecycle model. Its web based structure allows for sharing and reuse of other authors' learning resources. Thus the types of lifecycle information that can be collected within the ResourceCenter are manifold. A common problem with the collection and utilization of lifecycle information are the breaks the system borders for example between the authoring and provision or the authoring and re-authoring steps. Since the ResourceCenter resides in three of the four lifecycle phases it is suited perfectly for the gathering and utilization of lifecycle information and can serve as a proof of concept. Figure 2 shows the phases of a learning resource's lifecycle, where the ResourceCenter takes part in, and the kinds of information which are generated in these phases.

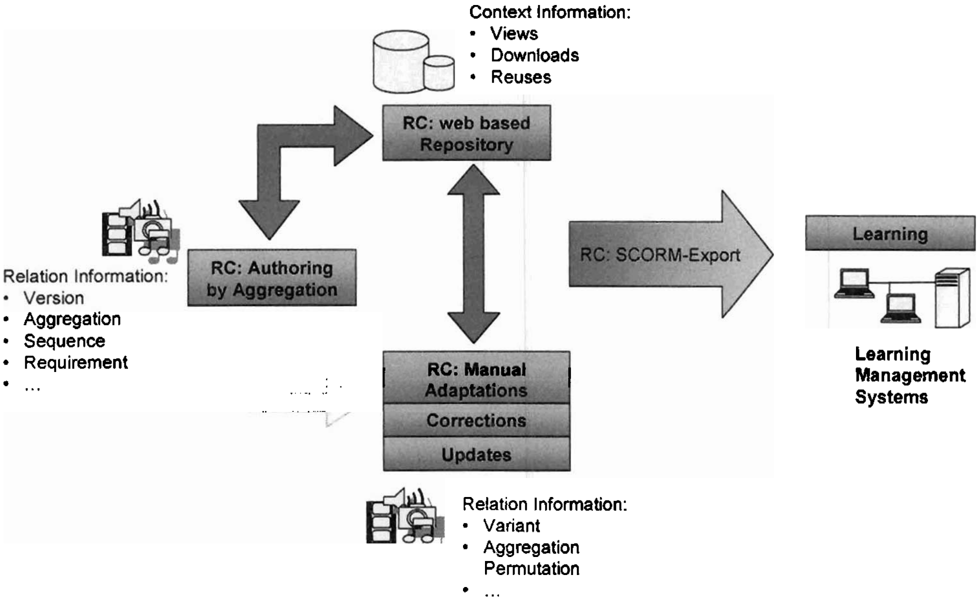


Figure 2: The ResourceCenter in the Learning Resource Lifecycle

4.2 Capturing and Management

There are different kinds of lifecycle information that can be gathered in the ResourceCenter. The *repository* component mainly generates *context* information which is described in the following:

- Number of *views*: Here we distinguish between the number of views on the whole and the number of views by different users. Every time a user opens the detail view of a learning resource, the counter is updated.

- Number of *downloads*: Again, the total number of downloads, or downloads performed by different users can be distinguished. Similar to the capturing of the number of views, a counter is updated every time a learning resource is downloaded from the repository.
- Number of *re-uses*: Since the ResourceCenter supports the re-use of other author's learning resources, it is easily possible to capture the number of times a learning resource is actually re-used. In order to achieve that, a counter is updated every time a learning resource is reused. For media resources like images or animations it is sufficient to add to the counter every time the resource is included in a course or section and to subtract from the counter if it is excluded, accordingly. For learning resources actually changeable within the ResourceCenter it is more complicated. We decided to add to the counter every time a section or course is included into a new course, no matter if it is changed and adapted afterwards or not.

In addition to these, nearly all of the relation information named in chapter 3 can be captured in the ResourceCenter, too, as described in the following:

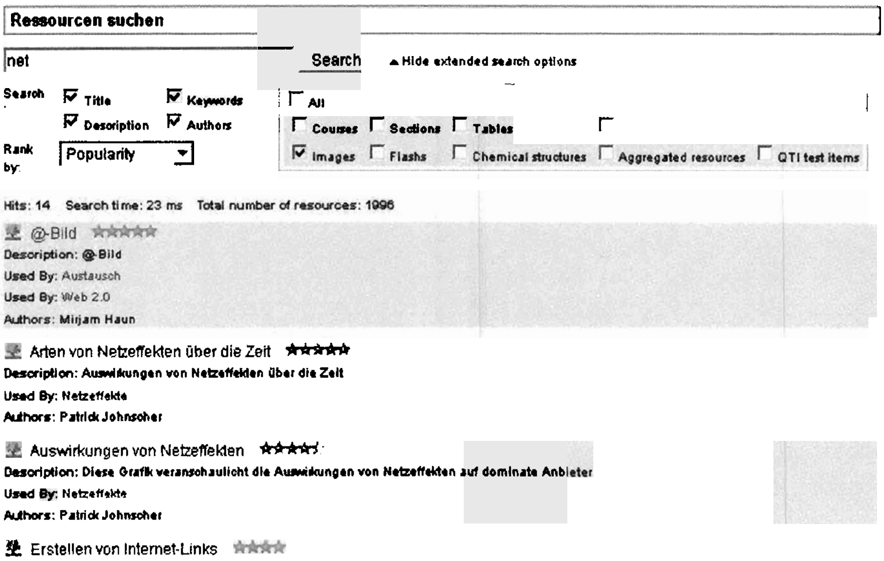
- *Aggregation* relations seem to be the most intuitive to collect in an authoring by aggregation environment. They are easy to capture and provide valuable information for authoring and retrieval. These relations are generated every time an existing resource is included in a course or section. In that case, an *isPartOf / hasPart* relation is created, that links the aggregated resources.
- *Sequence* relations can occur between sections and between media resources. When sections are put in a consecutive order they are connected by an *isPredecessorOf / isSuccessorOf* relation. This also applies to media resources, which have a certain, author defined order within a section.
- If two courses consist of the same sections in a different order, they can be connected via a *permutation* relation.
- Due to the fact that it is possible to define learning paths for a course in the ResourceCenter, *requirement* relations can occur between sections along the path. If an author, while he is defining the learning path for a course, defines a section to be required for the learner in order to understand a second section, an *isRequiredBy / requires* relation is generated.
- If an author removes sections from a course, or adds new ones in order to build a new course, the two courses are connected by an *isReductionsOf / isExtensionOf* relation. This also applies to the addition and removal of media resources from sections.
- *IsVariantOf / hasVariant* relations occur when an author edits a learning resource of a second author as well as in all cases of adaptations, not covered by the relations named above. We use hash values to check whether the content of a course or section was changed or not.

In the ResourceCenter the well known LOM standard (LOM 2002) is used for storing the metadata of the learning resources. With over 60 fields to fill it is quite complex. Unfortunately none of the existing fields matches our needs for the storage and management of the named lifecycle information exactly. For the relation information seventh LOM category - relation - seems to be an adequate basis. We decided to store the relation information in that category using the vocabulary shown in chapter 3. To achieve this, we adapted the Dublin Core vocabulary (Dublin Core), recommended for this category, to match our special needs. For the context information like the number of views and re-uses, we did not find an existing LOM category to start from. Thus we decided to place this kind of information in a new category, used for administrative purposes as well.

4.3 Utilization

Solely capturing the context and relation information for the learning resources in the ResourceCenter has no added value for the authors and other users of the ResourceCenter. The captured information has to be made available to the users under the right circumstances and has to provide new, helpful functionalities. In the ResourceCenter we currently make use of lifecycle information in three ways. On the one hand, the *retrieval* of learning resources can be made more comfortable.

Users in the ResourceCenter have the option to rank their search results in terms of the popularity, depicted by the number of views in combination with the number of downloads and in terms of reusability, depicted by the number of re-uses. Additionally they have the possibility to show the ten most popular or reusable learning resources of the different learning resource types. An example for a search result ranked by the popularity of the learning resources is shown in figure 3. This figure shows, how context and relation information are brought together to receive the highest possible outcome for the user. Learning resources are in the most cases searched over metadata. Therefore good search results largely depend on the quality of the metadata, which, what is well known, can be quite fluctuating (Duval et al.). With the help of lifecycle information the search results can get much better while being largely independent from the quality of the metadata. The relation information can simplify the search in terms of providing links to related resources. For example: If an author found an interesting media resource, the sections and courses it is contained in might be interesting for this author, too. Via the course he might find other interesting media resources he can use in his courses, in spite of not knowing the titles or descriptions of these resources. Figure 4 shows the detail information of a section.



net

Search ☑ Title ☑ Keywords ☑ Description ☑ Authors

□ All
□ Courses □ Sections □ Tables □
☑ Images □ Flashs □ Chemical structures □ Aggregated resources □ QTI test items

Rank by: Popularity

Hits: 14 Search time: 23 ms Total number of resources: 1996

@-Bild ★★★★★
Description: @-Bild
Used By: Austausch
Used By: Web 2.0
Authors: Mirjam Haun

Arten von Netzeffekten über die Zeit ★★★★★
Description: Auswirkungen von Netzeffekten über die Zeit
Used By: Netzeffekte
Authors: Patrick Johnscher

Auswirkungen von Netzeffekten ★★★★★
Description: Diese Grafik veranschaulicht die Auswirkungen von Netzeffekten auf dominate Anbieter
Used By: Netzeffekte
Authors: Patrick Johnscher

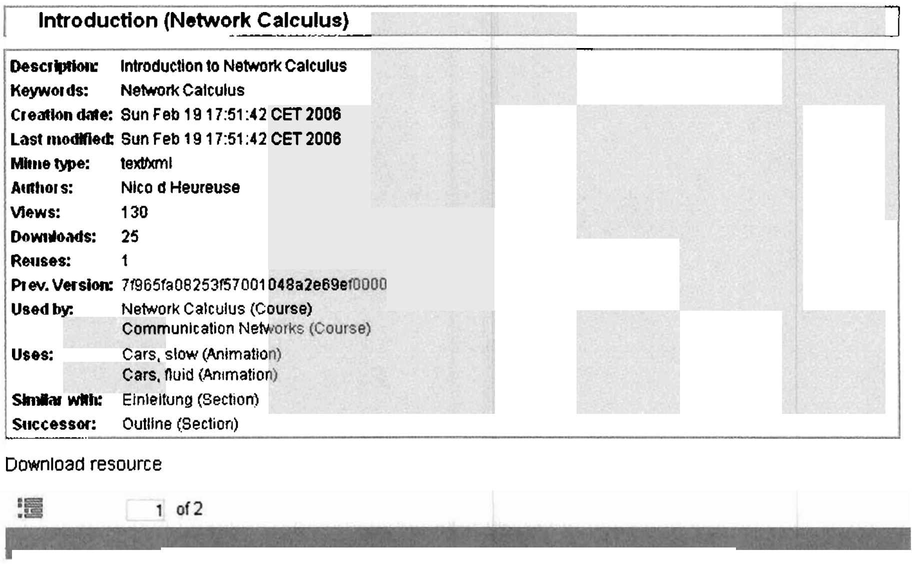
Erstellen von Internet-Links ★★★★

Figure 3: ResourceCenter Search Result

In this example, the animations used in this section (*'Cars, fluid*' and '*Cars, slow*') might be helpful analogies for an author who found this section while searching for resources he could utilize for his course about scheduling mechanisms. Without the added information he would have probably never found these, because he might not have been thinking of searching for 'cars' to find a resource related to his topic, while searching for 'network' matches his topic better and initially got him to the shown section. This is only one example, where the provision of relation information can be useful for the retrieval of learning resources. According to this, users in the ResourceCenter have the option to have resources added to the shown search result, if they are connected to a direct search hit by means of special relations like aggregation relations. Thus, users can configure their search in a way, so that resources that are i.e. aggregated with a resource containing a search concept are shown as search result as well.

On the other hand, lifecycle information can be helpful during the *authoring process* itself. An author can be provided with information about other authors' learning resources he is actually reusing, e.g. by notifying him when a new version is available or new relations were added. In addition to that he can even get information about learning resources he created, being re-used by other authors. The added value here is providing an author with suitable information at the adequate moment. In order for this to be helpful the author can configure, of which events he likes to be notified. One author might find it e.g. helpful to know, when one of his media resources is put into another author's section and he wants to be provided with a link to this section, while a second author doesn't.

At last lifecycle information can be used to help the author *evaluate* his work, by generating statistics of his learning resources. So an author can keep track of who is using his resources, what changes are made to them and how often his work is re-used or downloaded. If enough data has been collected it might as well be possible to tell what a re-usable learning resource has to be like.



Introduction (Network Calculus)

Description:	Introduction to Network Calculus
Keywords:	Network Calculus
Creation date:	Sun Feb 19 17:51:42 CET 2006
Last modified:	Sun Feb 19 17:51:42 CET 2006
Mime type:	text/xml
Authors:	Nico d Heureuse
Views:	130
Downloads:	25
Reuses:	1
Prev. Version:	7f965fa08253f57001048a2e69ef0000
Used by:	Network Calculus (Course) Communication Networks (Course)
Uses:	Cars, slow (Animation) Cars, fluid (Animation)
Similar with:	Einleitung (Section)
Successor:	Outline (Section)

Download resource

1 of 2

Figure 4: Detail View of a Section with Relation Information

5 Related Work

Actually there are no systems utilizing lifecycle information, like context and relation information, in order to support authoring, retrieval and processing of learning resources. Nevertheless there are quite a few systems actually utilizing different kinds of lifecycle information. This especially applies to *context* information, which is regularly used in marketplaces like Amazon (Amazon 2006) or eBay (eBay 2006) to generate recommendations and links to related topics. Context information is also considered in current research, for example by Najjar et al. who try to collect lifecycle information for learning resources in their Attention Metadata system (Najjar et al. 2006) or in various works on information retrieval dealing with recommendation systems (Good et al.). However, all of them concentrate on context information only. HyLOS (Engelhardt et al. 2005 and 2006), an e-Learning content management system for hypermedia based content, collects lifecycle information to support the generation of constructivist learning paths. It uses an extension of the LOM (IEEE 2002) metadata standard to store the semi automatically generated information. Unlike in our approach, relation information managed in HyLOS resides on a higher semantic level and is therefore not useful to support a user in authoring and retrieval of learning resources, but to provide alternative learning paths. For the ResourceCenter itself, there are quite some approaches covering parts or single components like ARIADNE or MERLOT, which are mainly repositories for learning resources but have components for authoring, like the ARIADNE course composer, as well (ARIADNE 2006, MERLOT 2006).

6 Conclusion and Future Work

It has been shown that lifecycle information can provide valuable functionalities to authors and users of repositories as well as authoring environments. We implemented these functionalities in the ResourceCenter, which has proven to be a good basis for the development of a proof of concept in this area. However, although the implementation of our concepts with the ResourceCenter was an intuitive task to do, it still hast to be shown that our approach is applicable in a generic environment. Here, the main question will be about how to transport the gathered information across system borders, which do not exist in the ResourceCenter. For the ResourceCenter a solution for this will be of advantage, too, since the information gathered in the learning phase might provide interesting functionalities as well. Furthermore, for future considerations it will be interesting to determine not only learning resources but knowledge documents in general.

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