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Modularization of Existing Learning Resources for Repurposing

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Abstract. Reusability of Learning Resources often fails because the existing Learning Resources are not available at the proper level of granularity. Hence, an ex post modularization is necessary to nevertheless re-use parts of these Learning Resources. The major research question, which I want to address in my Ph.D. work, is how modularization of existing Learning Resources for different re-use purposes can be performed efficiently and in a user-friendly way.

1 Background & Motivation

E-Learning has gained an important role in education, and especially in professional learning. Web-Based Trainings (WBT) allow learning at home or at ones desk. But although E-Learning has been used for some years and is a focus of many research projects, repurposing of E-Learning courses is still a challenge. Today, re-use is mainly thought of as re-use "as is", which means that a course is used again for another learner or group of learners, but in its original, unchanged form. However, reusing complete courses unchanged is often insufficient. If a learner wants to learn only a part of a whole course, he does not want to seek within a course those chapters which are relevant. Also, an author sometimes wants to re-use parts of one course for creating another course – either with another topical focus or for another target group and hence using different didactics. In these cases, having modular content available at a finer level of granularity would significantly improve the situation. Production of fine-grained, modular content is often demanded. But in practice authors do not obey for different reasons: planning and authoring of modular content takes more time and thus produces higher costs; and secondly deadlines for content delivery are usually short. As a result, creation of modular content is a nice concept in theory, but does not work satisfactory in practice in many cases.
If content is though supposed to be re-used in the described manner, it has to be modularized ex post. Monolithic Learning Resources have to be transformed into smaller, reusable modules. The process of transforming a Learning Resource into one

or more smaller Learning Resources for re-use is called *modularization*. In my Ph.D. work, I focus on methods for modularization of existing Learning Resources for subsequent repurposing.

2 Identification of Problems in the Field of Research

In order to support modularization of Learning Resources, several problems have to be solved. The most important challenges identified so far are:

- Granularity of Learning Resource fragments
- Identifying reusable Learning Resource fragments
- Requirements on modules for subsequent aggregation
  Transformation of suitable fragments into reusable modules
  Retrieval of suitable Learning Resources

The first challenge is to identify the proper granularity of Learning Resource fragments that are suitable for repurposing. A fragment is every part of a Learning Resource, which can be clearly separated from the rest of the Learning Resource; Learning Resource fragments are also called *content fragments* or simply *fragments* in this paper. Therefore everything from a single sentence over chapters up to the whole course can be regarded as a fragment. The question, which range of fragment sizes is suited best for repurposing, is still open. But as authoring of larger courses by aggregation is a possible usage of the resulting modules, the module granularity may be smaller than that of a traditional Learning Object.

The second challenge is to identify those fragments within a Learning Resource, which are suitable for a particular purpose. What is suitable for re-use depends on the user's purpose. Reusable fragments may be determined by different criteria such as topic, didactical functions or involved media types.

The modularization process shall result in modular Learning Resources, which can be re-used immediately or for aggregation into larger courses. Therefore, it is required to analyze and specify the requirements on modular Learning Resources. These requirements comprise technical aspects (formats), appearance (layout and design), didactic aspects, and possibly legal aspects as well.

When reusable fragments have been determined and the requirements on modular content are known, the fragments have to be transformed into modular Learning Resources which are suitable for aggregation. The challenges here are not only the technical decomposition but also include producing clean modules: There should not remain void references to unavailable parts of the original Learning Resource, neither technical (e.g. links in HTML), nor textual references. Also, depending on the chosen granularity, some texts like an introduction, summary or bridging texts have to be adapted.

And finally, retrieval of suitable Learning Resources remains a challenge. Sometimes, already modularized content might be available in a learning object repository. But more often the user has to find Learning Resources, from which he may re-use parts by modularizing it. Thus, it is necessary to find Learning Resources not only by their overall properties, but also by properties of individual reusable parts.

3 Overall Approach

For solving the research question, the whole modularization is divided into smaller issues. The modularization of a Learning Resource can be modeled as a process, which consists of several consecutive process steps. By splitting the process into smaller steps, the requirements on the whole modularization process can be assigned to the different process steps.

The basic approach is to model a modularization process which makes use of supportive functionality by a repurposing framework. The framework shall be used as an abstraction layer to the Learning Resource contents: it provides facilitated access to the Learning Resources regarding structure, contents and semantics. The modularization process is arranged between retrieval and re-use (see Fig.1). A retrieval component is used for finding Learning Resources that contain suitable contents for re-use. After the modularization process, different re-use components may process the resulting modules. Possible re-use scenarios could be aggregation, rearrangement or adaptation of modules.

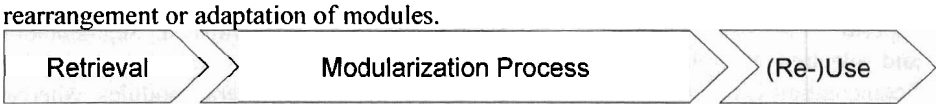

Fig. 1. Modularization process environment.

There are many different tasks which have to be performed for modularizing a Learning Resource. These tasks may also differ for different Learning Resource formats and re-use purposes. However, all relevant tasks shall be clustered into a smaller number of process steps for facilitating the planning, implementation and discussion of modularization methods. The process steps should be ordered, so that the results of one step are only required by successors, but not by predecessors. I have chosen to organize my modularization process in six process steps (see Fig. 2): they are consecutive; each of these steps has its own challenges; but each process step is defined precise enough to address and solve the corresponding problems. The six process steps are:

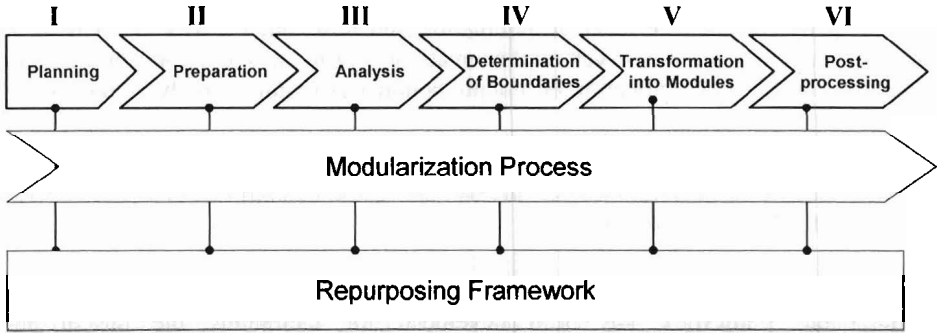

Fig. 2. Steps of the modularization process.

I) Planning. In the planning phase, the modularization goal has to be determined and methods and criteria to apply have to be identified. This includes the intended re-use

purpose for the resulting modules and also the question which criteria to apply (contents, didactic and media criteria) and which module granularity to chose.
II) Preparation. Before modularization can take place, a preparation may be required. If a Learning Resource exists in an arbitrary format, it might be desired to transform it into a format that is better suited for re-use. If SCORM content is modularized, it is recommended to break large Shareable Content Objects (SCOs) into smaller SCOs or assets first, and also remove internal navigation elements of the SCOs.
III) Analysis. In a further step, the Learning Resource fragments are analyzed regarding different criteria, which may have impact on the determination of reusable fragments. The analysis comprises properties of the contents of fragments, their didactic functions and media properties. Content properties, for example, may be covered topics, similarity of fragments or references between fragments.
IV) Determination of module boundaries. Based on the information, which has been collected in the previous process steps, the fragments that are to be re-used are chosen. Usually, resulting modules are supposed to be consistent and self-contained; but depending on the re-use purpose, a deviation from this principle might be superior. Two basic kinds of modularization are to be distinguished: Segmentation and selection; though these two kinds are supposed to appear combined in practice. Segmentation is a partitioning of a Learning Resource into several modules, whereas selection decides which fragments are re-used and which are not.
V) Transformation into modules (decomposition). The transformation step realizes the determined module boundaries by decomposing the Learning Resource. The resulting modules are made compatible to a predefined modular Learning Resource format, which is suitable for the intended use. If, for example, the result is supposed to be integrated into a larger course, the modules have to be aggregateable.
VI) Post processing. The results of decomposition are very often not yet suitable for re-use. There are still references to Learning Resource fragments, which no longer exist in the target modules, contents have become inconsistent and old metadata records do no longer fit the new modules. These shortcomings have to be eliminated in a post processing step. Not all of these tasks can be automated – some require a manual intervention of the user.
These six process steps cover all necessary tasks for modularization of existing Learning Resources. The level of automation and how much a user is involved in manual tasks may differ between implementations. For my proof of concept, I assume that especially the determination of module boundaries requires involving the user as decision maker.

4 Recent Contributions

Some contributions have already been made for enabling modularization. A repurposing framework has been developed for facilitating the design and implementation of repurposing applications [4]. It is suitable for a modularization application, but also allows adapting Learning Resources to different learning or teaching contexts. Additional components may be connected to the framework for

realizing the content analysis methods, which are required for the analysis step of the modularization process.
The current version of the Shareable Content Object Reference Model (SCORM) does not support aggregation of packages to larger units. I have developed an extension to SCORM, which enables to aggregate Learning Resources by reference [5]. This extension of SCORM will be the primary target format for modularized content for my proof of concept implementation.

5 Current Solution Approaches and Work in Progress

5.1 Preparation of Learning Resources for analysis and decomposition

There are many existing courses which are labeled as SCORM compliant but use SCORM only as a wrapper for arbitrary content. In the worst case, the package contains only one single SCO, which provides an internal navigation for the whole course. Modularization can be facilitated by decomposing SCOs first into smaller SCOs or assets. The decomposition comprised determining the SCO's internal structure and making it explicit; and also to identify and remove navigation elements of the SCOs.

5.2 Statistical analysis of content fragments

Methods for statistical analysis of Learning Resource fragments are currently evaluated, and are already showing promising results. There are two approaches for unveiling topics of and correlations between fragments. The first approach transfers text segmentation methods to Learning Resources. Calculating pair-wise statistical similarity of fragments allows detecting topic shifts within a Learning Resource. The second approach is based on the hypothesis that Learning Resources and fragments of Learning Resources are similar to Wikipedia articles that are concerned with the same or similar topics. I currently work on methods for predicting covered topics and especially topic shifts by the comparison of content fragments at different levels of granularity to Wikipedia articles.

5.3 Interactive GUI for Module Boundary Determination

The third issue which is currently worked on is an interactive graphical user interface (GUI) for the determination of module boundaries. A preliminary implementation visualizes the structure of a Learning Resource and lets the user assign module boundaries. The goal of the GUI is to support the user's decision making by providing him all necessary information. Hence an important research issue is: Which information is necessary for the determination of module boundaries and how should it be presented to the user? This question is strongly related to content analysis.

6 State of Art and Discussion

The need for modularization of existing Learning Resources has already been expressed in other scientific works. Duval and Hodgins mention in their LOM Research Agenda *decomposition* as an open research issue [2].
A guideline for the transformation of existing course materials into reusable learning objects is provided by Doorten et al. [1]. That work describes a manual decomposition process for domain experts, which is focused mainly on didactic properties of course materials and how to achieve self-contained learning objects. There exists a lot of authoring tools for Learning Resources which provide decomposition into smaller units. However, this functionality is often limited to exporting a chapter within the course structure, which has to be manually selected by the user. Examples for such tools are the Reload Editor, which may export a part of a SCORM package as a new package, and the Phoenix editor, which can be used for creating documents with pedagogic markup. Phoenix enables the decomposition of pedagogic units which have been created as reusable units before [3]. Another project which targets at decomposition of Learning Resources is ALOCoM. ALOCoM decomposes slide presentations and enables the re-use of individual slides for new presentations [6].
My solution differs from the existing approaches for different reasons. First of all, there is no approach known to me that supports the whole modularization process by a technically-integrated solution. Existing solutions are either guidelines for manual modularization or do not support the whole process from retrieval to the final modular contents. Also, existing approaches do not take into account that Learning Resources have to be modularized differently for different re-use purposes. And finally, available approaches do not sufficiently regard the role of the user as the real decision maker, who has to be supported by providing adequate information.

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