

Supporting Modularization and Aggregation of Learning Resources in a SCORM Compliance Mode

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Abstract

Modular Learning Resources that can be aggregated to larger Learning Resources are crucial for the future success of E-Learning. Re-use of Learning Resources will only reach significant numbers, if not only re-use "as-is" is supported, but also aggregation and adaptation to a new teaching or learning context.

This paper analyzes requirements on a format for Learning Resources that supports modularization and aggregation. A suitable format based on SCORM and LOM is proposed and afterwards evaluated by means of a tool implementation.

1. Introduction

Over the last years, E-Learning has gained a major role in education. E-Learning technologies are commonly used in academic and professional education. Small enterprises currently buy off-the-shelf courses from content producers, because the production of dedicated material is too expensive. Basis for this paper is a scenario where modular Learning Resources are distributed via an open internet marketplace. In this scenario, a user might want to build his own course out of whole or parts of available Learning Resources – possibly also using some self-created content.

In order to enhance reusability, Learning Resources should be obtainable at different levels of granularity. As today's Learning Resources are available mostly as monolithic courses, there is also a need to modularize and aggregate existing Learning Resources. Modularization can be understood in this case as a transformation of a monolithic module into an aggregate of smaller modules.

This paper analyses the requirements for a Learning Resource format, which supports modularization and aggregation, proposes an extension of SCORM as a solution and presents a tool implementation as evaluation.

2. Module format requirements

Learning Resources within this scenario have to be stored, delivered, processed and (re-)used. We use the term Modular Learning Resource, or module, for Learning Resources that conform to certain requirements, which are listed below. In the scenario, it is assumed that most content will be available as either SCORM packages or arbitrary collections of HTML files. A format for modules should support aggregation and modularization of modules. Also important is a reliable versioning concept that allows to track updates or parallel versions (variants) of other modules.

Seven main requirements have been identified for a modular Learning Resource format:

Universality. A module has to be able to contain arbitrary content. All (digital) formats should be valid content formats.

Metadata. The format should allow keeping metadata about the module together with the module, because availability of metadata is crucial for re-use.

Support for aggregation. Aggregation of modules to larger modules must be possible. This requirement refers to two levels: metadata level and content level. On metadata level, aggregation equals inclusion dependencies between modules. Content level aggregation means that the content is integrated, so that it appears as one coherent Learning Resource. *Distribution of aggregated modules.* It must be possible to (re-)distribute aggregated modules.

Versioning. The module format must support versioning. Updates (revisions) and variants of modules have to be marked as such. Different versions of one module may exist at the same time.

Enable update mechanisms. It must be able for tools to track updates of modules and to replace old versions with newer ones. This is a challenge especially if an outdated module is part of an aggregated module.

Low technological barrier. Users must not be excluded by high technological requirements.

3. Related work

Rensing et al. have described the need for modular Learning Resources [1]. They also emphasize the need for aggregation and modularization of Learning Resources.

The de facto standard for exchanging E-Learning content between different authoring tools and learning management systems is the Shareable Content Object Reference Model (SCORM) [4]. A common format for describing Learning Resources with metadata is IEEE Learning Object Metadata (LOM) [2]. The content of a Learning Object is seen as binary data only; aggregation is regarded only on a meta level. How aggregation of the content looks like is not specified. Also, the semantics of aggregation relations are ambiguous and not ready for extensive use [3].

An implicit versioning scheme for Learning Resources has been developed by Theilmann et al [5]. This versioning scheme addresses the issues of link versioning and potential conflicts that may occur when multiple versions of the same Learning Resource are aggregated.

Hörmann has proposed to use aggregation as basis for a complete authoring process [6]. Authoring-by-aggregation is a paradigm that forces the user to build Learning Resources bottom-up.

4. Using SCORM as base format

As result of the investigations presented before, LOM and SCORM have promising features, but do not fully match the identified requirements. We have decided to base our module format on SCORM. The reasons were:

- There are already many SCORM compliant courses available.
- Arbitrary contents may be packaged as a resource in an IMS Content Packaging package.
- The technological barrier for extracting arbitrary content is low – only a standard archive tool (zip) is needed.

- Metadata can be shipped with the module as a LOM record in a SCORM manifest.
- Aggregation as required may be realized with only little changes.
- Versioning and aggregation information can be stored in the LOM record.

5. Extensions to SCORM

Some of the requirements are not yet satisfactory matched by SCORM and LOM, especially for versioning and aggregation. Thus, some extension had to be made, which are in detail:

5.1 Versioning

Versioning is implemented using LOM category 7. The concept of implicit versioning from Theilmann is adopted. Each version of a module gets its own unique module ID, for which Universally Unique Identifiers (UUID) [7] are employed. When a new version is created, the ID of the original module is written to the metadata record as a predecessor relation. Beside the module ID, a module also has a distinct path relative to a common root directory. In consequence, the relative URL between two modules never changes, so that file references may exist across module boundaries. A module path should be unique for each module to avoid conflicts. However, versions keep the module path of the original module, because otherwise all inter-module references would have to be updated when a module is replaced by a newer version.

5.2 Aggregation

Aggregation of Learning Resources is realized as aggregation by reference. Thus, redundancies can be minimized for the sake of less storage space demands of the repository. Also, the update of aggregated modules is easier: When a new revision of an integrated module is available, only the references from the aggregating module to the included module have to be updated.

Technically, aggregation is realized on two different levels: on metadata level in LOM and on structural and content level in IMS Content Packaging / SCORM.

On metadata level, an aggregation relation is modeled in the LOM record of the aggregating module as a reference to another module ID. This relation is used mainly for retrieval and delivery issues. Aggregation relations in LOM always reference a particular version of a module.

On structural level, aggregation is achieved by connecting the Content Packaging manifests of modules. The referencing manifest contains a XInclude tag [8], which points to the referenced manifest file. The included manifest file is handled like a regular sub-manifest by tools.

5.3 Preserving SCORM-compliance

Extending SCORM to support modular Learning Resources has one drawback: Compatibility is broken, because most SCORM tools cannot handle the extension correctly. Therefore, SCORM-compliance has to be reestablished. This is done by the generation of an aggregated SCORM manifest that consists of all module manifests. All files are integrated into one single SCORM package, which is fully SCORM-compliant. The original module manifests remain within the aggregated package in order to enable reusing the individual modules.

6. A proof-of-concept implementation

The proposed format has been evaluated by implementation of a proof-of-concept tool. A module editor has been developed that handles SCORM packages including the described extensions. That tool also supports aggregation and modularization of modules and versioning.

Modularization is currently implemented in a basic form: the user selects an item from the SCORM manifest which is transformed by the tool into a new SCORM package. After separating the modules, a reference to the newly created module is inserted in the structure of the original module at the position where the sub module's content has been before.

The implemented module editor has shown that the proposed format is suited for modular Learning Resources in practice. Aggregation of Learning Resources is as well possible as modularization of one Learning Resource into smaller ones. In addition, the described versioning system allows keeping track of the various versions of the modules.

All requirements have been validated by the implementation. Available SCORM courses have been successfully imported and modularized; new versions have been created and finally exported. Also, modules can be exported as SCORM-compliant courses.

7. Conclusion and outlook

In this paper, we have described a scenario where modular Learning Resources are used for creation,

distribution and re-use of E-Learning content; and we have proposed a format for modular Learning Resources, based on SCORM and LOM.

The evaluation shows that all requirements are fulfilled by the proposed format for modular Learning Resources. Issues for improvement are seen mainly in the tools that support the described format for modular Learning Resources, providing better usability to users.

A main focus of future work will be sophisticated modularization methods. We plan to support the user by providing him more information on the content of the Learning Resource and to propose reasonable module boundaries.

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9. References

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