ROADMAPS – NAVIGATIONAL AIDS AND TOOLS FOR REUSING CONTENT IN DISTANCE EDUCATION

Jörg R. Mühlbacher, Michael Sonntag
Institute for Information Processing and Microprocessor Technology (FIM)
Johannes Kepler University, Linz, Austria

Introduction

Because in the production learning material is very costly to create, the aim of providing reusability is as important as it is for any software as well. But additionally reusability in e-learning also covers re-use of organisational structures (manifests) including course syllabus and other navigation vehicles as roadmaps, which we will discuss in particular. We focus on the IMS content package standard (as a convenient example) and, based on it, we discuss other possibilities, e. g. how a simple treelike and therefore hierarchical structure can be enriched by additional paths. The result is a general acyclic digraph and we present examples, why it makes sense that a learning path starting with a lesson S and ending with lesson F not necessarily should be unique. It is exactly this possibility of providing alternatives, which offers reuse of content. Through small additional metadata this also allows reusing a course in the sense of easily creating several different versions from it, e. g. for different audiences. As a proof-of-concept at the end we briefly present the extensions to an existing tool for creating an off-line view from manifests: Visual roadmaps and deriving subversions from a single manifest.

Standards for assembling content in distance education

There are (too) many standards being developed and hopefully they will converge in the future. Among the involved institutions and/or standards are of particular importance the Dublin Core Metadata Initiative (DCMI) [3], Institute of Electronical and Electronic Engineering (IEEE) [4], IMS Global Learning Consortium (IMS) [5], Alliance of Remote Instructional Authoring and Distribution Networks for Europe (ARIADNE) [6], Aviation Industry CBT Committee (AICC) [7] and the Advanced Distributed Learning Initiative (ADL) [8]. Currently there are working groups active in order to promote standards for e-learning or to contribute to a "standardization of standards."

At the time being it seems that a wide agreement on standards for content packaging will be reached, respecting the demand for backwards compatibility. However, concerning metadata, this seems to be much more difficult because metadata also refers to domain related semantics. Even within the same domain currently particular local (national) interest influence content initiatives[1].

In this paper we use the IMS Content Packaging Specification (CPS) as an example and base for the prototype. The reader is referred to [2] and we recall here only what is necessary to understand the concepts "manifest", "submanifest", "metadata" and "organization" (of which the navigation is an essential part). The IMS CPS consists of two major components: A so-called "Package Interchange File" and the resources (the physical files) as such (which we will not discuss here; we are "only" concerned with navigation between them). Figure 1 illustrates these components. In the sequel the "physical files" will be of no concern and therefore we skip any further explanation.

[1] See e. g. the Austrian metadata standard for electronic teaching material [9].

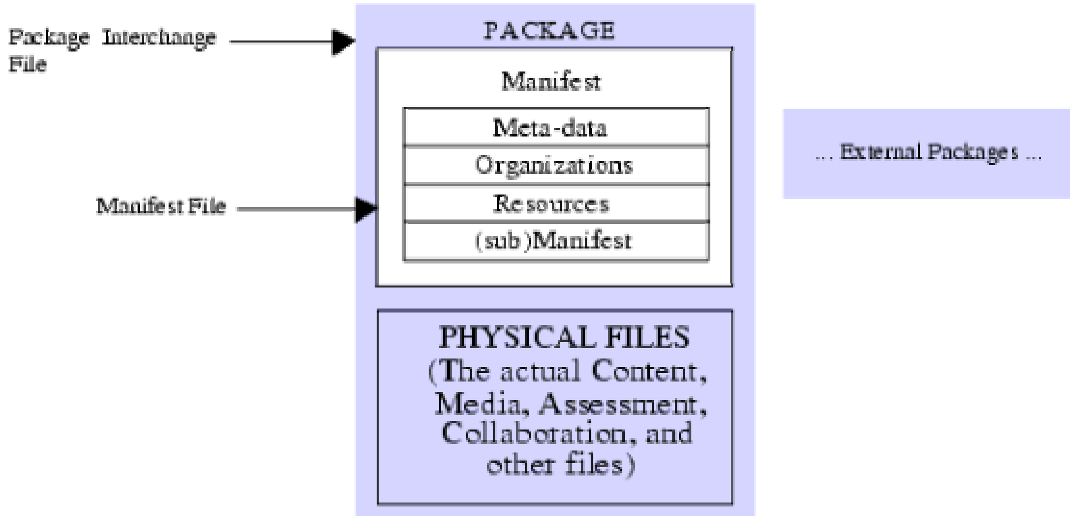

Figure 1: IMS Content Packaging scope [2]

The Package Interchange File is an xml file (imsmanifest.xml) including at least one manifest. The top-level manifest describes the package itself and may also contain (sub-) manifests. Each manifest consists of metadata (information describing the manifest as a whole), an organizations section (structure of the course and usually source for creating navigation within actual content), a resource section (references to actual data elements; the course content) and optional submanifests. Through this the IMS CPS separates physical learning resources from their actual use and organisation.

The original specification however explicitly forbids recursive references. In the simplest case, the organisation either does not contain any other submanifest at all or only submanifests that are entirely disjoint. In that case the underlying abstract course navigation is described best by the familiar decimal classification and current viewing tools handle this as expected. In terms of graph theory this is just an (oriented) tree. An advanced navigation (using a slightly relaxes specification) however should provide an acyclic digraph, which allows figures as shown below. Here the navigation suggests implicitly to the learner to make a decision either to follow the "informal" path or just jump into a strict "definition of the subject", before approaching to have a look at some examples. But both branches can be visited in any order anyway, as it would be possible in a decimal notation as well.

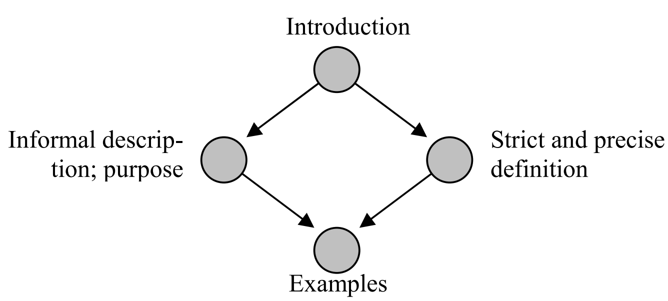

Figure 2: Sample of different navigational paths

In the general situation, however, the resulting navigation graph could contain cycles, in particular if submanifest are being used recursively. In other words: if somewhere within the organization a reference to a submanifest is made, which has been included on a "higher level" before already. We do not discuss here whether this concept is useful from a pedagogical perspective or not. Current editors (e.g. the one included in [12]) are not able to cope with recursion. While parsing the manifest they are locked in an endless loop or produce a recursion stack overflow.

Roadmaps in e-learning material

By a “roadmap” we understand a graphical representation of the general structure of the content. The concept of “roadmaps”, e.g. using an underground network, which is familiar to many people, is being used already in many courseware products as an alternative to the traditional standard decimal (or hierarchical) classification which we see in books and as it is implied by the simple IMS manifests. The point here is however, that we want to separate the underlying logical structure (graph) from its visualisation for the learner (decimal–classification shape, tree, underground map…). This issue is ignored very often and therefore it is worth underlining the difference between a graph and any of its many possible graphical representations.

The following example describes why there is a need to separate both concepts. Think of the complex structure or London’s underground system. It is logically best described by a graph. If train lines are crossing at different levels etc., then this is intrinsic to the graph structure. However this is of no concern to the passengers. If it would be shown on the tube diagram it would confuse passengers. The visualisation of the underlying graph follows an overall design principle: apart from the yellow circle line every line is shown on the map in a way that either “Northbound/Southbound” or “Eastbound/Westbound” can be perceived immediately. This exactly is the “master strategy” for orientation within London’s subway system.

At this point we add, that basically also a three dimensional visualisation is possible, but we omit a discussion of such general spatial models here.

There is an intrinsic meaning associated with the nodes and links of such a graph X=V(X),E(X)).This semantic is expressed by labelling the nodes V(X) and the links E(X) by words from using an appropriate metalanguage: <u,v> obviously suggests to proceed from node u to v. Nodes u from V(X) represent either a reference to a simple resource, e.g. a html file, a pdf document etc., or (recursively) reference the organizational part of a submanifest. In order to simplify the notation in the following and being aware that nodes are pointers to a content, we can avoid this indirection and just state that nodes represent resources. It must be clear, that this simplification does not imply that the physical files (see Figure 1) are now part of the organizational structure of a manifest; the necessary separation still exists.

If we put all the above arguments together, we can distinguish between two loosely connected aims: (1) automatically extracting a formal graph definition (e.g.: adjacency matrix) out of the organisational structure of a given manifest, even if the manifest is more complex then just a hierarchical structure resulting in a tree, and (2) a convenient drawing and labelling of the graph, so that the resulting “picture” together with the semantics of the labels helps the learner finding his or her way through the available material easier. It also should be clear that some kind of hidden additional information may be brought in by the overall layout of the drawing, e.g. similar topics could be drawn close together, whereas rather different issues might be drawn farer away.

This additional information is very hard to encode in a text and reveals at the same time an interesting dilemma. Either the person who draws the roadmap must possess extensive knowledge about the covered subject or the metadata specifications should contain additional elements describing e.g. the relevance of the content of submanifests compared to the main theme.

Role in reusing content

As far as reusing material is concerned we focus here on an advanced level only, namely reusing entire manifests as submanifests within another one, which we call a “metamanifest” then. This possibility is provided to some extent by the IMS CPS. In this case navigation is presented by combining the navigation structures of the parts. In terms of graph theory it means that nodes can be replaced (“expanded”) by another graph, which becomes a subgraph. A restriction implied by CPS however is that a general network structure is not possible in the following sense: if a reference to a submanifest or a reference from a submanifest to a sub-submanifest etc. is made, then all this sub-….-submanifests must be a priori part of the same metamanifest. If strictly adhering to the specification, manifests can only reference manifests contained within them (but not on any other level, neither above nor siblings). For this discussion we do away with this restriction and allow more freedom[2]. The specification of the CPS is similar to restrictions in some operating systems supporting only static linking (the concept of DLLs is not provided for). With respect to reusability this means that on the one hand somebody else's manifest "A" can be (re) used because "A" is copied entirely into the metamanifest "M". But on the other hand, if the original author modifies the manifest "A" to "B", this has no effect on "M" because "M" still contains "A" statically.

The first conclusion with respect to reusability is, that submanifest can easily be used and because everything is assembled into the metamanifest's file together, this file can be easily parsed without needing any other files and the resulting graph structure calculated. The latter covers acyclic digraphs and therefore cycles (recursions) are in particular forbidden. Apart from this, reusability is restricted in terms of static linking as stated above.

A challenging application of reusability however is the design of a course addressing e.g. two different target groups, but which at the same time contains chapters (submanifests) which are of interest for both groups and should be made visible for both of them. All other chapters should be visible and accessible only by the target group in question. In this way only a single (albeit a bit more complicated) manifest must be maintained and modified for changes to appear in all related courses.

Using IMS and LOM specifications for implementation

While it may seem tempting to include the information for a roadmap as a new organisation into a manifest, this leads to several problems. Changes in the (sub-) manifests or the main organisation must be manually transferred to the roadmap-organisation (or the editing tool must do this automatically; currently none such exist). This also models the roadmap as something completely different and independent from the parts (a property pertaining only to the whole metamanifest), while it actually is a logical consequence of the individual parts and their arrangement. Therefore it should be represented either as metadata within the submanifests, or as metadata of the references to them. As whether a submanifest should be a roadmap item or not depends more on the combination of several of them, respectively the kind of integration of the submanifest into the metamanifest, this information should be put into the reference. As the actual metadata element for deriving the roadmap, the "aggregation level" of the LOM specification [1] can be used. It ranges from 1 (atomic element) over 2 (lesson) and 3 (course) to 4 (higher elements). A roadmap typically shows items of level 2 (see next chapter for an example). The visual annotation can be anything, but using the associated title seems sensible. The person rearranging the resulting graph for visual presentation could always change it later.

The reuse of submanifests for several courses at once in a single file can best be implemented by introducing "taxonomy" metadata. These can be incorporated to both the submanifest itself as well as the reference. As the most appropriate purpose-element we selected "Educational Objective". For describing different courses, this element might be subpart of either an official or private (e.g. course numbering system within the institution; see example below) taxonomy.

Another issue is including submanifests from separate files instead of having to import (and re-import upon changes) them physically as mentioned above. This is included in the specification only as a suggestion for further development (most probably using XInclude [10]). Ways around this are tools already supporting this construct or using standard XML methods (e. g. external entity references; they are however not really suited, or intended, for this). A related problem is that organisation IDs must be unique only within a single manifest. If several manifests are included into a metamanifest (regardless whether statically or dynamically), collisions might happen. This requires rewriting IDs upon inclusion or other provisions (e. g. namespaces). For the rest we assume this problem solved.

[2] Resulting in more responsibility by the creator: He/she must now ensure that all referenced submanifests are actually contained somewhere in the metamanifest. Simple copying the main manifest into it will not suffice any more because other manifests (not physically contained) might be needed.

Sample Implementation

For the use within the WeLearn framework [11, 13] (Web Environment for Learning; an online learning platform) developed at the institute a converter for offline viewing was created as well. It receives one or more IMS manifests as input and creates one or several offline views. Through this the content of the platform can be used very similarly offline too (and is in practice distributed on CDs). This converter understands and handles submanifests either according to the standard or in way more compatible to the Microsoft LRN viewer [12] (user configurable). Previously, only minimal metadata was used (title, keywords, description). This was enhanced to also understand parts necessary for the reuse of submanifests for different courses and the automatic creation of roadmaps. As currently no editor (short of textually editing the XML source) is available to us, this is used only for testing and a second mode was introduced. In this (functionally equivalent) mode the metadata required is incorporated into the “parameter” value of items or references (and extracted to identical metadata).

The offline version of the roadmap is somewhat restricted in the sense that it does not show the current position graphically, but only allows navigation within the course (no “active” graphic). This is intended as an optional addition for later versions. The online version to be introduced into the WeLearn system itself will offer this feature right from the start.

See the following abbreviated snippet from a sample manifest for the two possibilities of specifying the additional information in a reference to a submanifest: Either in the parameters of the item or as associated metadata.

```
<item identifier="METAMANIFEST_ITEM" identifierref="SUBMANIFEST_ORG"
        parameters="taxonomy=353.001,353.002;aggregationlevel=2">
<classification>
  <purpose>
    <source><langstring xml:lang="x-none">
        LOMv1.0</langstring></source>
    <value><langstring xml:lang="x-none">
        Educational Objective</langstring></value>
  </purpose>
  <taxonpath>
    <source><langstring>JKU course numbering</langstring></source>
    <taxon><entry><langstring>353.001</langstring></entry></taxon>
  </taxonpath>
  <taxonpath>
    <source><langstring>JKU course numbering</langstring></source>
    <taxon><entry><langstring>353.002</langstring></entry></taxon>
  </taxonpath>
</classification><title>Submanifest 1</title>
</item>
```

Conclusions

In DE reusability of learning material is essential, as it is very cost-intensive to create. In order to avoid stranded investments, it is necessary to follow standards. Also, the learning material itself must not be structured rigidly, but as flexible as possible. Nowadays this flexibility is most often not given; therefore nearly the same learning material must be developed several times. E.g. parts of a course in object-oriented programming could be reused in special programming courses on C++, JAVA or C#, and be adaptable to other target groups as well (e.g. a beginners course in computer science, in schools, etc.). The use of submanifests, although requiring some additional effort, is a step in this direction.

Integrating small additional metadata or using the existing structure of submanifests can then produce the additional benefit of a different way of navigating the content which is (at least for some learners) superior to a tree-like structure. Such a roadmap enhances orientation within the course, eases remembering certain parts and allows globally planning a way instead of requiring individual decisions at each point (with very limited range of sight: next page or subitems). In an online version this roadmap can also show the current position, the previous way, or also the location of other learners, in this way enhancing awareness. Through this all, results of learning can be improved, while incurring only very small additional costs through adding at some places pieces of special metadata.

Acknowledgement

This paper is a result of the project “Integrating Agents into Teleteaching-Webportals“ sponsored by the FWF of Austria (Fund for the support of scientific research; Project number P15947-N04).

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Authors

o. Univ.-Prof. Dr. Jörg R. Mühlbacher, Mag. Dipl.-Ing. Dr. Michael Sonntag
Johannes Kepler University Linz, Institute for Information Processing and Microprocessor Technology (FIM), Altenbergerstr. 69, A-4040 Linz, Austria
{muehlbacher, sonntag}@fim.uni-linz.ac.at