MobiLearn: An Open Approach for Structuring Content for Mobile Learning Environments

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Abstract. Mobile devices are becoming more and more important in the context of e-learning. This requires appropriate models for structuring and delivering content to be used on various devices. Different technical characteristics of devices as well as different needs of learners require specific approaches. In this paper we propose a model for structuring content that allows rendering for different devices like Notebooks, PDAs, and Smartphones as well as presentation of the content in different levels of details according to didactic concepts like case study, definition, example, interaction, motivation, directive. This approach allows adaptation of content (device, granularity of content, content selection based on didactic concepts) at run time to specific needs in a particular learning situation. The approach realized in the joint MobiLearn project of several universities in Austria shows high acceptance by students during an initial pilot application.

1 Introduction

E-learning is going to become a standard element in many educational environments. Approaches and solutions range from very simple FTP-like download-oriented sites to websites providing a high degree of administrative services like student administration and organisation of course material for large student populations. Usually these solutions treat digital learning material as preorchestrated, canned content, very often available as one single piece of material by means of e.g., some slide presentation or PDF-file to be read electronically or in printed form. Since several types of mobile devices like PDA or Smartphones became highly available for students the demand of mobile learning scenarios is significantly stimulated.

As part of a concerted activity for creating innovative e-learning environments the universities of Vienna, Linz and Klagenfurt and the Vienna University of Technology started the MobiLearn project[1]. It aims at offering digital content

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from the domain of "Medieninformatik" composed in a form that specifically serves mobile learning teams and exploits the WLAN-enhanced infrastructure already provided at the university sites. The project is based on e-learning scenarios that take into account learning any time any where, i.e., providing digital content in the class room, at the PC or notebook of a student, at a PDA or Smartphone, depending on the needs of students and of course on the capabilities of the devices used. Students also should be supported in terms of collaborative learning in small teams.

The MobiLearn approach avoids creation of preorchestrated content, but allows to come up with highly modular content that can be combined as needed by teachers as well as students and that can be made available in proper form for the various output channels like online PC/notebooks, online or offline PDAs or Smartphones as well as for offline print products. MobiLearn content is not available in terms of single, downloadable files, but is accessible by means of different views, e.g., a view that very much fits the traditional way of presenting a subject in a class room at an European university, a view that meets the needs of students just starting out learning from examples, a view that prefers the presentation of definitions and concepts to focus more on models and theory, a view that only contains the essential issues by means of questions that may be part of an examination later on.

Given these application scenarios it is quite obvious that content needs to be structured such that it can be used for the various purposes of a any-time-any-where scenario. This paper addresses the approach taken to support the creation and management of such kind of structured content. Section 2 presents the approach taken for modelling and structuring the content. Section 3 presents architectural issues relevant for the realization of the approach. Section 4 addresses the open issues that need to be worked on or turned out to be critical for the overall success. Section 5 concludes the paper and gives some details on the first version of the prototype deployed at the participating sites.

2 Structuring Content

2.1 Structuring Courses: Learning Unit

In order to be able to process logical pieces of content according to the application scenario given above it is required to have well-defined means of structuring content. There are several approaches one can find in related projects, e.g., the LaMedica project[1], the Cardio-OP project[2][3][4] that already provide semi-structured content in some way. These approaches either follow some proprietary model or rely on (quasi) standards that facilitate structuring content, e.g., the approaches taken by ADL SCORM[5] or IMS[6], that mainly follow and are based on the IEEE LOM standard[7].

It is quite obvious and well accepted to structure content by means of "learning objects". But there is still no definite answer to the question of what a learning object is. The Learning Object Metadata Working Group of the IEEE

Learning Technology Standards Committee (LTSC) provides a very global definition: "Any entity, digital or non-digital, which can be used, re-used or referenced during technology supported learning"[7]. David A. Wiley in [11] - criticising the existing confusion created by the loads of definitions that are either too broad or too narrow - provides a more focused working definition for learning object: "any digital resource that can be reused to support learning".

To avoid any ambiquity, for the purpose of the MobiLearn project, we use the term of *"learning unit"* defined as self-contained unit of learning, ranging from 15 minutes to 45 minutes. Each learning unit is independent and can be reused as is in multiple contexts for multiple purposes ("black-box-reuse"). Learning units are aggregated to *modules*. The volume of a module corresponds to a typical class, i.e., it corresponds to about 1-2 ECTS points. Technically, the aggregation of learning units to modules is realized according to the IMS Content Packaging Specification[6]. Following the IMS Specification increases the interoperability of the learning content between different management systems. Furthermore, a collection of modules, called *course*, may be used to form a whole educational programme.

So far we rather have a very traditional structuring schema. The distinctiveness of the MobiLearn project is the way we structure learning units. The model considers the new learning paradigms without losing the connection to the traditional learning content. A student, on her way to exam, recalling the outlines of a given subject, using her PDA, is accessing the same content as some student, sitting at home and just starting to read a lecture about the same subject on his Notebook. Thus a single learning unit has to be deliverable at various devices, has to provide for varying degree of intensity of content and even for its semantic aspects at very low level. Fig. 1 shows the conceptual model of aggregating and structuring learning units in the MobiLearn project by means of an UML diagram. It shows that learning units are composed of presentation units characterized by a *level of detail (LOD)*, an indicator for the intended use of the material. Each presentation unit consists of blocks carrying an optional header and data (text, figures, etc.). Blocks are intended to be rendered for specific devices, e.g. PC, PDA or a Smartphone. Intuitive examples of types of blocks are *Definition* representing a formal definition of some subject, *Example* representing some example on a subject, *Interaction* representing some interactive element on a subject.

The subsequent sections describe the key concepts of the structuring scheme: structuring according to didactic aspects, multichannel delivery, and level of details.

2.2 The Concepts of Learning Units

Didactics. Didactic aspects of learning content gain in importance every day. Students look for direct access to certain parts of a lecture "on demand" during various phases of learning instead of going through all the material again and again. One way to solve this problem is to write really small learning units and to annotate them with proper metadata (e.g., according to Learning Object

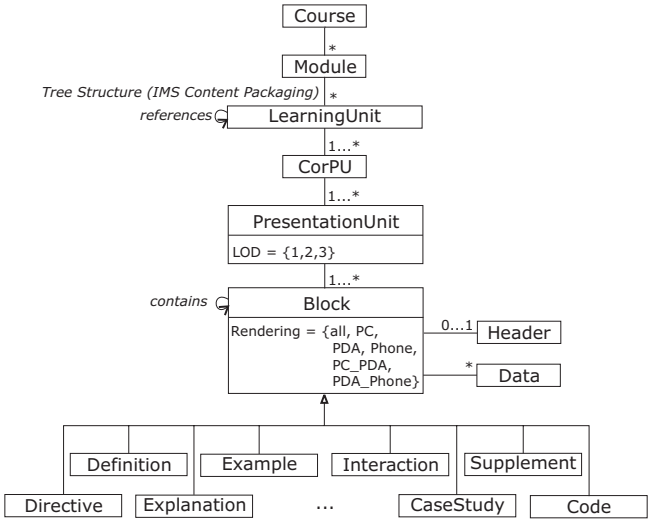

Fig. 1. Conceptual model of learning unitl

Metadata[7]. The way we choose to go is to tag every single paragraph or even whole section(*"Block"*) while writing the content. Authors don't have to annotated the material later on and users can easily filter the relevant aspects of the given learning unit or even of whole modules.

The following XML snippet shows and example of a proper annotated learning unit:

```
...
<LearningUnit>
    ...
    <Definition>
       <Header>XSLT</Header>
       <Data>
          Extensible Stylesheet Language Transformation (XSLT)
          is a language for expressing transformation of XML
          documents from one form into another.
       </Data>
       <Explanation>
          <Data>
             A transformation process expressed in XSLT describes
             rules for transforming a source XML tree into a
             result tree that can be another XML document, an
             HTML document, or any other text format...
          </Data>
       </Explanation>
    </Definition>
```

```
    ...
</LearningUnit>
```

In the MobiLearn project we have defined a set of 16 didactic elements based on evaluation of existing didactic schemes and our rich teaching experience. Nevertheless the collection of elements is defined in such a way that it can be easily extended with minimal change of the XML Document Type Definition (DTD) that encodes the elements and without any destructive effects to existing content:

```
<!ENTITY % BlockType
  " CaseStudy | Code | Content | Definition
  | Directive | Example |  Exercise |  Explanation
  | Information | Interaction | Motivation | Quotation
  | References | Summary | Test | Theorem ">
```

Multichannel Delivery. The MobiLearn project considers three categories of devices - Notebooks and Personal Computer, PDA, and Smartphone - with different capabilities and limited resources related to display size, processing power and communication bandwidth. Thus the presentation of the content has to be adapted to the learning device on the fly. Automated transformations from XML-coded base content into *device-specific presentation* is supported (see Fig. 2 and Fig. 3).

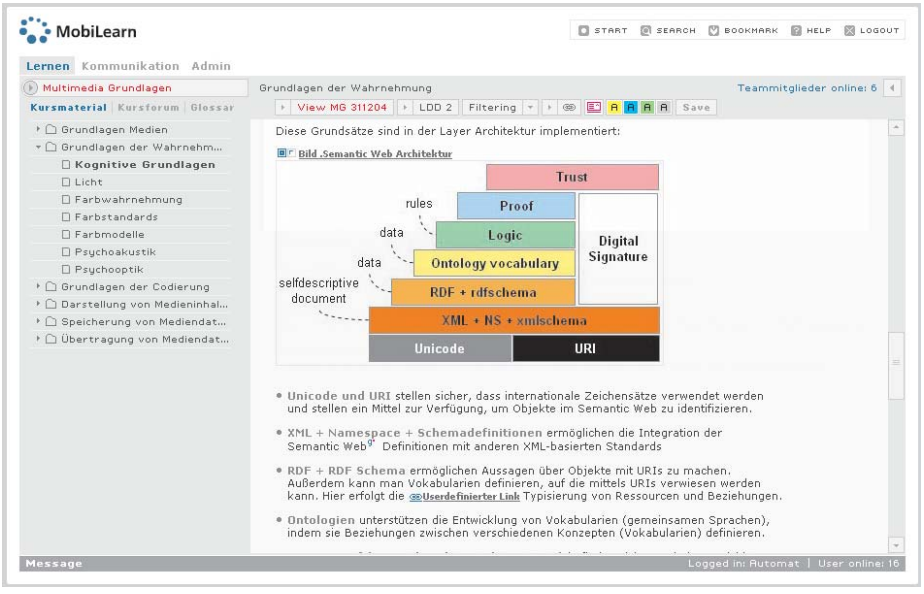

Fig. 2. Device-specific presentation for Notebook

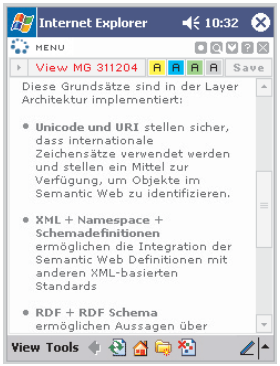

Fig. 3. Device-specific presentation for PDA

Device types are annotated by appropriate attributes at the block level:

```
...
<LearningUnit>
    ...
    <Example Rendering="PC">
       [Encoding of content with e.g., big images, table]
    </Example>
    <Example Rendering="PDA">
       [Encoding of content only in textual representation]
    </Example>
    ...
</LearningUnit>
```

Again just a minor extension of the MobiLearn DTD with further attribute values allowed for the attribute "Rendering" is needed, if support of any further device is required.

Level of Detail. Learning units are sequential compositions of *presentation units*. A presentation unit is composed of one or more content blocks presenting given subject at the same level of granularity, encoded by means of - *Level of Detail*(LOD). The MobiLearn project considers three Levels of Detail:

1. *Level 1* gives an overview of the learning content. This level corresponds approxiamately to a slide view of the content used for lecture readings
2. *Level 2* represents the more comprehensive course material, a script format or maybe a kind of textbook of the learning content. This level is useful for students, who are not familiar with the subject and need to rely on more detailed material in order to understand the subject.
3. *Level 3* summarizes any additional information relevant to the subject and supporting the better understanding of the subject, including references to external materials and interactive elements.

Furthermore the three Levels of Detail are synchronized among each other, i.e. each Presentation Unit may have one or more corresponding presentation units at the other levels of detail. Thus switching between the available levels of detail is provided.

The following XML code illustrates the use of the LOD concept. Note, that the context of corresponding presentation units is established by the tag <CorPU> that contains presentation units assigned to different Levels of Detail.

```
...
<LearningUnit>
    <CorPU>
       <PresentationUnit LOD="1">
          [Content in a slide view, keywords]
       </PresentationUnit>
       <PresentationUnit LOD="2">
          [Content in a textbook or script style]
       </PresentationUnit>
       <PresentationUnit LOD="3">
          [Additional information, references, examples,
          interactive element]
       </PresentationUnit>
    </CorPU>
    ...
</LearningUnit>
```

Users are able to choose content at different Levels of Detail depending on their current learning situation e.g., learning at home or refreshing content while on the move.

3 Architectural Design

Content stored as XML has one essential aspect: using different transformation processes it is possible to convert any XML-coded data into various widely used structured document formats ((X)HTML, SMIL, PDF, etc.). In [12] a quite common architecture for multi channel delivery systems for e-learning is presented. In that model XML coded data is adapted to the capabilities of the requesting device via appropriate transformation processes. In the MobiLearn project we expanded the transformation part of that model as we needed transformation processes considering all the three key concepts of the project (see Fig. 4). Thus such a model of multi channel delivery systems enables the adaptation of learning content to device, desired level of details of content and semantic aspects.

The model proves some remarkable advantages:

1. MobiLearn learning units are XML coded data. Hence *interoperability* is guaranteed between systems understanding the MobiLearn approach and structure of learning units fixed by a pre-defined Document Type Definition (DTD).

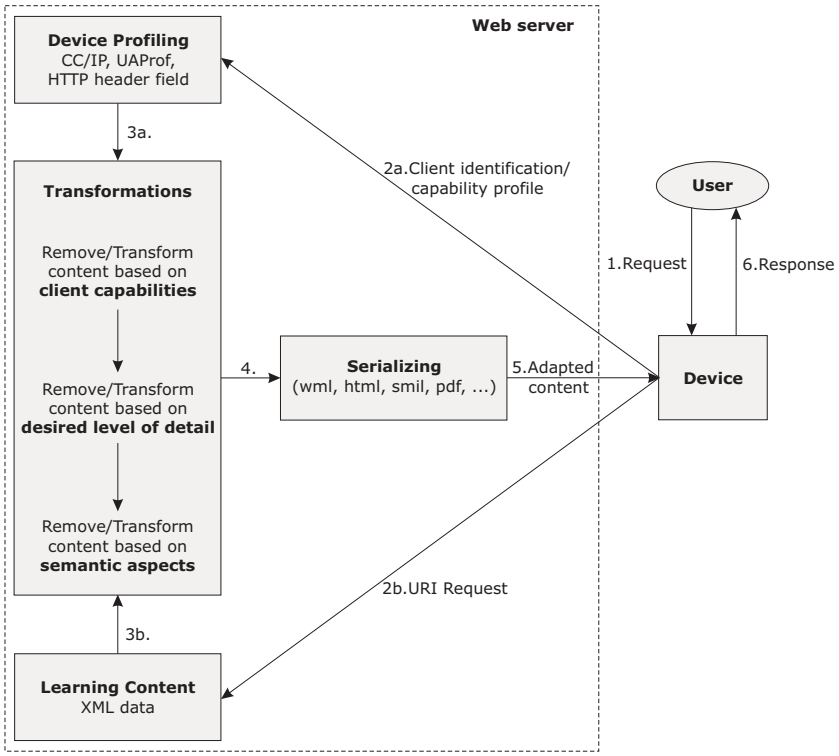

Fig. 4. Multi Channel Delivery System

2. The XML approach allows the definition of transformation processes (e.g. using the XML transformation language - XSLT[8], XSL-FO[9], or the XML query language - XQuery[10]). Such transformations enable easy *adaptation* of learning content to given requirements.

3. Transformation processes enable *delivery on the fly* as well as *delivery of offline content*. Delivery on the fly is used for online access to the content, where a quick adaptation to learners' requirements is requested. Still a lot of experts show significant preference for traditional printed material (see [13]) for reading, because learning online significantly reduces learning efficiency and speeds up the fatigues of the learners. An example for offline content are the traditional printed scripts (a kind of textbook). Still some advantages of the online content, i.e., its interactivity, potential animation, video or audio, are lost in printed material. For printed material, an easy connection to the lost multimedia elements was enabled by the idea of so called PaperLinks (see [14]). PaperLinks establish relationships between locations identified by e.g. barcodes in printed material and digital content.

4 Open Issues

Although the approach taken has been realized by the project consortium and a first version of the system has been put in operation, there are still many open issues that require further research and effort in order to find adequate solutions or improve existing solutions. One of the most important issues is the complexity and the degree of freedom of the Document Type Definition that specifies the details of the structuring according to the scheme given in Fig. 1. The richer the structuring primitives given by the various block types and their possible composition the more complex the authoring process. From the given experience of the project partners it is absolutely essential to have a WYSIWYG authoring system that fully supports the primitive concepts including level of details, rendering types, and didactic elements.

Another very important issue is to provide guiding rules during the authoring process that support an author in composing the blocks like definitions, explanations, or examples. Such guiding rules should not be "hard-wired" into the system, but should be configurable such that different didactic models can be supported. It should not be expected that teachers always agree on the pedagogical model and the underlying didactic building blocks. Hence, configurability of the composition schemes allowed is an essential requirement for the authoring system.

Another critical issue is the availability of an adequate e-learning platform. In our case we have available the SCHOLION system (see [15][16]) that has been initially implemented by the University of Linz and that has proved its applicability and usability already in the context of many classes. In the MobiLearn project that platform has been redesigned and extended to meet the specific requirements of the project. The platform needs to support the fine-grained structuring of the digital content in terms of it services, otherwise a user cannot exploit the added value of highly structured course material. Unfortunately, no one of the widely used and well known e-learning platforms provides enough support for structured content as given in the MobiLearn project. Even the possibility to import MobiLearn content by means of IMS compliant packaging does not solve the problem, as all the structuring within a presentation unit (see Fig. 1) is lost after importing and not made available for the user because of missing functionality of the e-learning platform.

These issues are considered to be most critical and there is significant further research effort needed to improve authoring tools and platform.

5 Conclusion

In this paper we presented a model for structuring content for a mobile e-learning environment. The structuring scheme incorporates didactically classified pieces of content (encoded by means of "Blocks"), that can be delivered to and rendered for individual device types (following the multi channel delivery approach and essentially covering PC or Notebook, PDA, and Smartphone), presented in different information intensity (encoded in terms of levels of detail), respectively.

The project follows a very modular approach: didactic elements can be easily defined and introduced by means of "Blocks" just by extending the predefined set of didactic XML elements in the MobiLearn DTD. Further device types can be easily supported by extending the set of attribute values allowed to be choosen for the rendering attribute at the block level. And even the level of semantic granularity of the content can be extended by introducing another level of detail in case the three levels of detail, currently choosen in the project, do not sufficiently fit particular learning needs.

We consider the openness and interoperability of the approach as a big advantage and strength compared to other approaches that either do not provide fine grained structuring of content or only provide hard-wired models that cannot always be adapted to specific needs.

Given our experience we can conclude that powerful tools are needed for authoring and presenting e-learning material composed according to our approach. Although we have specific tools available in our project environment, we consider the development of more suitable collaborative authoring tools as essential as the improvement of the e-learning platforms. Our future work will focus on these issues among the incorporation of the experiences resulting from operating the MobiLearn system in the teaching context of the different universities involved in the project.

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References

1. Friedl, R.; Preisack, M.B.; Klas, W.; Rose, T.; Stracke, S.; Quast, K.J.; Hannekum, A.; Godje, O.: Virtual Reality and 3D Visualizations in Heart Surgery Education. Heart Surg Forum. 2002; 5(3):E17-21. PMID: 12732500 (2002)
2. Klas, W.; Greiner, C.; Friedl, R.: Cardio-OP: Gallery of cardiac surgery. IEEE International Conference on Multimedia Computing and Systems 2:1092- 5 (1999)
3. Friedl, R.; Preisack, M.B.; Schefer, M.; Klas, W.; Tremper, J.; Rose, T.; Bay, J.; Albers, J.; Engels, P.; Guilliard, P.; Vahl, C.F.; Hannekum, A.: CardioOp: an integrated approach to teleteaching in cardiac surgery. Stud Health Technol Inform 70:76-82 (2000)
4. Friedl, R.; Klas, W.; Westermann, U.; Rose, T.; Tremper, J.; Stracke, S.; Godje, O.; Hannekum, A.; Preisack, M.B.: The CardioOP-Data Clas (CDC). Development and application of a thesaurus for content management and multi-user teleteaching in cardiac surgery. Methods Inf Med. 2003; 42(1):68-78. PMID: 12695798 (2003)
5. ADL Sharable Content Object Reference Model (SCORM) Version 1.3 (January 2004) http://www.adlnet.org/

6. IMS Content Packaging Specification v1.1.3 (July 2003) http://www.imsglobal.org/content/packaging/
7. 1484.12.1 IEEE Standard for Learning Object Metadata (June 2002) http://ltsc.ieee.org/wg12
8. W3C Recommendation. XSL Transformation (XSLT). Version 1.0 (November 1999). http://www.w3.org/TR/xslt
9. W3C Recommendation. Extensible Stylesheet Language (XSL). Version 1.0. October 2001. http://www.w3.org/TR/xsl/
10. W3C Working Draft. XML Query Language. November 2003. http://www.w3.org/TR/xquery/
11. Wiley, D.A.: Connecting Learning Objects to Instructional Design Theory. In D. A. Wiley (ed.), The Instructional Use of Learning Objects. Agency for Instructional Technology and the Association for Educational Communications and Technology. ISBN: 0-7842-0892-1. (2002)
12. Topland, K.O.: Mobile learning. Technological challenges on multi-channel e-learning services. Master Thesis. Agder University College, Norway (2002)
13. Mills, C.B.; Weldon, L.J.: Reading text from computer screens. ACM Computing Surveys 19/4 (1987)
14. Hitz, M.; Plattner, S.: PaperLinks - Linking Printouts to Mobile Devices. MLEARN 2004, Italy (2004)
15. Froschauer, B.; Stary, C.; Ellmer, M.; Pilsl, T.; Ortner, W.; Totter, A.: SCHOLION - Scaleable Technologies for Telelearning. Proceedings of the 2000 ACM Symposium on Applied Computing, Como, Italy, ACM (2000)
16. Auinger, A.; Stary, C.: Embedding Self-Management and Generic Learning Support into Courseware StructuresProceedings of the 35th Hawaii International Conference on Systems Sciences, IEEE (2002)