[EGFSt00] *Abdulmotaleb El Saddik, Amir Ghavam, Stephan Fischer, Ralf Steinmetz;* **Metadata for Smart Multimedia Learning Objects**; Proceedings of the fourth Australasian Computing Education Conference. ACM Press, New York, USA, December 2000, **Seiten fehlen noch.**

Abdulmotaleb El Saddik, Amir Ghavam, Stephan Fischer and Ralf Steinmetz. "Metadata for Smart Multimedia Learning Objects" In proceedings of the third Australasian conference on Computer science education, ACSE '2000, Australien Dec. 2000

Metadata for Smart Multimedia Learning Objects

Abdulmotaleb El Saddik[1], Amir Ghavam[1], Stephan Fischer[2], Ralf Steinmetz[1,2]

[1]KOM - Industrial Process and System Communications
Darmstadt University of Technology
Merckstrasse 25
64283 Darmstadt, Germany

[2]IPSI, German National Research Center for Information Technology
Dolivostrasse 15
64293 Darmstadt, Germany
+49-6151-8694838

{Abdulmotaleb.El-Saddik, Amir.Ghavam, Ralf.Steinmetz}@kom.tu-darmstadt.de
sfischer@darmstadt.gmd.de

ABSTRACT

The application of educational metadata is nowadays often limited to the description of static resources (text or image) in order to support the retrieval process. The usage of metadata is done in a static way with respect to the (static) content and cannot influence the multimedia content itself. An adequate description of dynamic multimedia content, for example animations, is also difficult.

In this paper we propose dynamic educational metadata as an extension of IEEE's Learning Objects Metadata (LOM) to describe multimedia content. These metadata can be used to customize the behavior of the multimedia object according to the user's needs. The term *customization* is normally used in the context of component software technology and applied in our context to denote changes and/or modifications to a multimedia learning object. These changes are necessary to match the learning goals of a user and to reuse dynamic multimedia content in a different context.

1. INTRODUCTION

Educational metadata became an important research issue in the last years, especially with regard to *standardization issues* of learning metadata, such as Instructional Management Systems (IMS) [1] or the efforts of IEEE's Learning Technology Standards Committee (LTSC) [2]. It is the goal of educational metadata to describe learning resources in a way that the content can be tailored for the needs of a targeted group, for example for students. The content to be described is normally built of hypermedia elements (texts, images, audio, video, animations) which have been stored in a modularized way.

These emerging standards will define a specification language and an environment for managing sessions in learning technology systems, e.g., computer-aided instruction, intelligent learning environments, or intelligent tutoring systems.

The standards will (1) define the specification language, conceptual models, semantics, and syntax, (2) define the control transfer mechanisms and their encodings, e.g., how learning sessions are controlled and conducted, (3) define the data transfer mechanisms and their encodings, e.g., how student assessments and lesson plans are exchanged, (4) define an encoding method for storing and transferring session management "programs", i.e., interactive lesson plans.

The Multibook project [3] currently being developed by the Technical University of Darmstadt and the Fern-Universität Hagen is a Web-based adaptive hypermedia learning system for multimedia and communication technology. Multibook focuses on providing end-users with specific lessons tailored to a targeted group. These lessons are created using a knowledge base of multimedia elements, especially interactive animations.

Multibook's knowledge base which is necessary to implement the course sequencing [4] consists of two separated spaces. The Concept Space contains a networked model of learning topics [5] and uses approaches well known from knowledge management. The knowledge topics are interconnected via semantic relations. The media bricks stored in the system are atomic information units of various multimedia formats. These units are interconnected via rhetoric relations. Each media brick is described using IEEE's Learning Objects Metadata (LOM) scheme [11]. In the following we refer to media bricks as *learning objects*. Although both information spaces are separated, each learning object can have a relation to one or more related topics. The separation of both spaces is the way in which Multibook generates adaptive lessons, because for each topic a set of media bricks (texts in different granularity, animations, video, etc.) is available. The selection of media bricks is then determined by the preferences of each user.

With respect to reusability, learning systems enriched by multimedia can be divided into two categories:

- Learning objects are relatively simple but described by metadata in detail. A learning system operates on the metadata with an intelligent knowledge.

- Learning objects are very smart in a way that they can change their behavior. A learning system has to pass specific information, and each learning object has to adhere to a particularly stipulated set of input/output parameters.

When working with media bricks and with the necessary educational metadata, an important disadvantage becomes obvious: Due to the history of the development of metadata, static resources, such as images or text documents can be described properly. Unfortunately, an appropriate description of dynamic resources, for example animations, is feasible only to a limited extent. The reason is that dynamic multimedia objects can process input parameters, generate output parameters, and also work internally with data which cannot be described in the traditional metadata schemes.

The approach described in this paper addresses the issue of customizing dynamic multimedia objects using *dynamic metadata*. We refer to these objects as *smart learning objects*. With the term *customization* we denote changes and/or modifications to a learning object. These changes are necessary to match the learning goals of a user and to reuse dynamic multimedia content in a different context. In order to describe such smart objects we introduce a new set of metadata which is an extension of IEEE's Learning Objects Metadata. We show how such metadata can be used by a metadata editor, which allows us to describe smart multimedia objects. Another tool to customize the resource according to the user's needs will also be explained in this paper.

The paper is structured as follows: In Section 2 we explain related work and define multimedia Learning Objects (LOs) as well as learning objects metadata. In Section 3, we present an overview of interactive multimedia content and their characteristics, before we introduce dynamic metadata in section 4. Section 5 describes our implementation, and Section 6 concludes the paper and gives an outlook.

2. BACKGROUND AND RELATED WORK

2.1 Multimedia Learning Objects

As stated in the specification of IEEE's Learning Objects Metadata (LOM) [11], "a learning object is defined as any entity, digital or non-digital, which can be used, re-used or referenced during technology-supported learning". Examples of Learning Objects include multimedia content, instructional content, instructional software and software tools, referenced during technology supported learning. In a wider sense, learning objects could even include learning objectives, persons, organizations, or events. A learning object is not necessarily a digital object; however, the remainder of this paper will focus on learning objects that are stored in a digital format.

The learning object (LO) model is characterized by the belief that independent chunks of educational content can be created that provide an educational experience for some pedagogical purpose. With regard to object-oriented programming (OOP), this approach asserts that these chunks are self-contained, though they may contain references to other objects, and they may be combined or sequenced to form longer (larger, complex, other) educational units. These chunks of educational content may be of any type, interactive (e.g. simulation) or passive (e.g. simple animation), and they may be of any format or media type.

Another requirement for learning objects is related to tagging and metadata. To be able to use such objects in an intelligent fashion, they must be labeled as to what they contain, what they communicate, and what requirements with regard to their use exist. A reliable and valid scheme for tagging learning objects is hence necessary.

The LO model provides a framework for the exchange of learning objects between systems. If LOs are represented in an independent way, conforming instructional systems can deliver and manage them. The learning object initiatives, such as IEEE's LOM or Educom's IMS are a subset of efforts to creating learning technology standards for such interoperable instructional systems.

2.2 Multimedia Learning Objects Metadata

The starting point for our research is the existing technologies, standards, and on-going initiatives with regard to multimedia educational metadata. The Dublin Core [10] Metadata Element Set, Educom's Instructional Management System (IMS) [13], the Alliance of Remote Instructional Authoring and Distribution Networks for Europe (ARIADNE) [12], and IEEE's Learning Object Metadata Working Group 12 [11] are the most important initiatives dealing with metadata for learning purposes. These initiatives are closely related to the Resource Description Framework (RDF) [16], the Warwick Framework [15], and to other activities of the World Wide Web Consortium.

The Dublin Core initiative [10] was an early effort to standardize what the core tags for general information objects should be, and has been remarkably successful with regard to the fact that most standardization efforts of learning content start with Dublin Core. The Dublin Core is now separately investigating the special case of educational objects, somewhat independently of other ongoing work.

IEEE's specification of Learning Object's Metadata (LOM) defines the following nine categories for metadata of a learning object which will be described in detail hecause of their importance for our paper:

- *General*:
  General metadata, such as the title, language, structure, or description of a LO
- *Life Cycle*
  Status, version, and role of a LO
- *Meta MetaData*
  Metadata describing the metadata used for a LO
- *Technical*
  All technical information about a LO, such as the format, the length, browser requirements, etc.
- *Educational*
  Information about the educational objective of a LO, such as interactivity, difficulty, end-user type, etc. (details see below).
- *Rights*
  Commercial use and ownership of a LO
- *Relation*

Implements a concept similar to hypermedia links to be able to refer to other LOs

- *Annotation*
  Used to provide additional, eventually more detailed information about a LO
- *Classification*
  Defines different purposes of a LO, together with its location within a taxonomy of keywords

Each of these categories groups appropriate metadata fields of a specific aspect.

With regard to our intention, the category educational is especially important. This category contains several types of tags:

- *Interactivity* type, covering the information flow between resource and user, with restricted values *active*, *expositive* (passive), or *mixed*.
- *Learning resource* type, describing the specific kind of resource (which can be a list, prioritized), and allows any terminology. Recommended values are *exercise*, *simulation*, *questionnaire*, *diagram*, *figure*, *graph*, *index*, *slide*, *table*, *narrative text*, *exam*, or *experiment*.
- *Interactivity level*, defining the degree of interactivity, and ranges from *very low*, through *low*, *medium*, *high*, to *very high*.
- *Semantic density* can store the same values, and is used to define a subjective measure of a resource's usefulness relative to size or duration.
- There are categories for intended end users (teacher, author, learner, manager), context of use (an open vocabulary, but examples include primary education, secondary, higher education, different university levels, technical schools, etc.), typical age range, difficulty (again, a range from very low to very high), and typical learning time.
- Also included are a text description of the resource, and a language choice from the international standard codes.

All of the methods used to specify metadata make use of metadata in the traditional sense of describing static data [7]:

- to summarize the meaning of the data (i.e. what is the data about).
- to allow users to search for data.
- to allow users to determine if the data is what they want.
- to prevent some users (e.g. children) from accessing data.
- to retrieve and use a copy of the data (i ß y.e., where do I go to get the data).
- to instruct how to interpret the data (e.g. format, encoding, encryption).

That is, the metadata descriptors are associated in a fixed way with the data sets. Their granularity is as defined by the original metadata author.

A great drawback is that the application of metadata is mainly limited to the above described fields where metadata are used in a static way with respect to the content. A first observation is that such metadata cannot describe smart dynamic LOs adequately. Metadata can also not influence the multimedia content itself, because metadata usually contain universal and widely applicable descriptions of objects. In our point of view, the usage of dynamic multimedia learning objects, such as animations, requires a new sort of metadata, which must be dynamic in order to facilitate the I/O behavior of a dynamic LO. In the following we will discuss the definition of smart learning objects before we define the necessary set of these metadata.

3. INTERACTIVE MULTIMEDIA CONTENT AND STATIC METADATA

With respect to reusability, learning systems can be divided into two categories:

- Systems which deploy learning objects that are relatively simple but richly tagged using metadata. Each learning system operates on metadata with a significant degree of own knowledge.
- Systems which use learning objects that are smart in a sense that they can change their behavior. The system has to pass specific information to a LO, and each LO has to adhere to a particularly stipulated set of input/output parameters.

An example of the first category is the use of IEEE's LOM in the Multibook project in order to describe multimedia content. However, multimedia content being part of learning systems can be text, graphics, audio, video, animation, or simulation. Simulations which visualize complex procedures dynamically and interactively, belong to the group of smart learning objects. The use of animated graphics or simulations is much closer to real life than still graphics are. Complex procedures can be experienced, understood and learned by experimenting in the virtual environment being offered by simulations. The behavior of smart learning objects can be changed, as well as adapted according to parameters which are passed by the system.

For the remainder of this paper we will denote interactive visualizations as *smart learning objects*.

As a part of the Multibook project we developed a component-based framework [6] in order to generate complex animations based on simple modules which visualize the steps of an algorithm. These modules are interactive multimedia Java applets which illustrate concepts and algorithms of multimedia communication technology. We use these components for the multimedia communication courses being taught at the Technical University of Darmstadt.

To be able to integrate these animations into our learning system Multibook, and in order to optimize their utilization, we tagged all animations using IEEE's Learning Objects Metadata.

Smart Learning Objects developed by a programmer may in many cases be converted to a series of animation sequences. An example would be a JPEG animation which can be split into four different animations visualizing the four steps of JPEG (image preparation, DCT, quantization, and entropy encoding). The generation of an animation sequence can be achieved by mapping algorithm variables, specifying animation actions, and associating execution points in the algorithm to perform the desired animation.

As mentioned above, LOM can be used to search, navigate, and adapt the content of Multibook as long as static learning objects are used. However, the particular potential of interactive visualizations, in other words their flexibility and adaptability, can only be exploited to a limited extent. For example, some interactive visualizations ean be used to illustrate different scenarios or different parts of an algorithm, depending on the parameters passed to them. The same learning object can hence be re-used in a different learning context, according to the way it is configured by parameters. Parametrization of interactive visualizations can be done off-line or on-line. In order to achieve an on-line customization, we propose the use of dynamic metadata as an extension of the static IEEE Learning Objects Metadata.

4. DYNAMIC MULTIMEDIA METADATA

We define the term "dynamic metadata" as the description used to adapt the content of an object, and/or to change the behavior of a learning object.

As an example of dynamic metadata, we will in the following examine the simulation of the CSMA/CD protocol (Ethernet). To be able to explain Ethernet properly, specific problems have to be addressed, for example the collision of packets on the bus, or the shortframe problem. The key idea behind dynamic metadata is that the same visualization can be used to explain different problems, if it is configured by parameters. In the following we will explain the data structures for dynamic metadata in detail, but to motivate the problem, we provide an example here. A part of the data structure could be a field "PROBLEM", addressing a specific parameter configuration of a visualization. Concerning the visualization of Ethernet, changing the value of the metadata field "PROBLEM" (being represented in the program as a property) from "Collision" to "Shortframe" may change the whole behavior of the algorithm to be visualized.

4.1 Extension of IEEE's LOM

As mentioned above we understand dynamic metadata as an extension of IEEE's Learning Objects Metadata. The scheme of dynamic metadata follows the generic format of <property, values, value type>. According to the LOM specification [11], this scheme is illustrated in Figure 1.

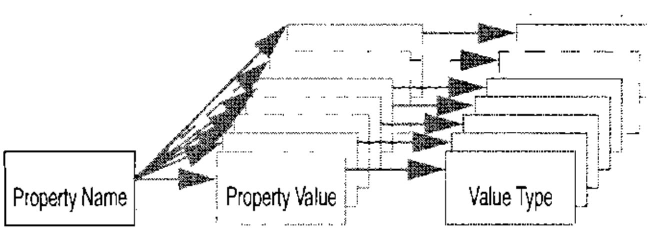

Figure 1. Generic scheme of dynamic metadata

In the following we analyze the requirements of the proposed set of metadata for dynamic content in detail.

- *Language*:
  LOM contains a field to store information about the language which is used within a LO. However, smart LOs enable the user to change that language. An example is Java's internation-alization framework where a set of language alternatives can be used. Although it would be possible to change the underly-ing LOM base category, we propose to use a new field within the new category "Dynamic Metadata" containing a list of pos-sible languages. The original LOM field could then be used to store the initial state of a smart multimedia LO.
- *DifficultyLevel*:
  Within the category "Educational", LOM contains the field "DifficultyLevel" that describes the difficulty of a LO on a scale from "very low" to "very high". With regard to hierarchi-cal modularized animation chains, such a choice is inappropri-ate. An example is an animation visualizing the steps of JPEG for a beginner. The level of difficulty would be "very low". A more advanced user could switch to animations of the single steps of the algorithm, an expert user could even change the components of the DCT formula. To be able to describe these difficulty changes, we introduce a new dynamic field "Diffi-cultyLevel" which indicates the degree of difficulty the resource should start with. The values should (like in the LOM base model) range from "very low" to "very high". Modular-ized hierarchical animations have for example been described in [7].
- *InteractivityLevel*:
  The same argumentation with regard to the field "Dif-ficul-tyLevel" is true for the degree of interactivity of a resource. While a beginner might use a visualization of a problem in a movie-like style, an expert might want to change parameters and thus use a highly-interactive application. We propose a new field "Interactivi-tyLevel", storing the degree of interactiv-ity on a scale from "very low", "low", "normal", "high", to "very high".
- *Bidirectional*:
  Some animations or visualizations offer the possibility to step forward or back within a smart LO. We propose to use a field "Bidirectional" indicating whether a step-back operation is possible or not.
- *Dimension*:
  For some animations it is necessary to specify the dimension of the container in which the visualization will take place.
- *Topic*:
  Many smart LOs like animations or visualizations explain an algorithm with multimedia elements. We propose to use a field "algorithm" to store the name of an algorithm. Another possi-bility would be to extend the meaning of the field "name" of the base LOM scheme. The disadvantage of the latter approach would be that a clear distinction between the parts of an algo-rithm would be impossible. An example is a JPEG animation where the field "name" contains the string "JPEG", while the dynamic metadata field "algorithm" might contain the string "entropy encoding".
- *Scenario*:
  A scenario is a specific form of an animation which is defined by a teacher and intended to explain a subset of the knowledge a smart LO could transfer. Similar to the field "algorithm", a smart LO can be used to visualize various scenarios. An exam-ple is a smart LO explaining Ethernet. Possible scenarios are for example "short-frame" or "collision". The new field "sce-nario" has a

general meaning as it can be identified in many smart LOs; it is somehow an alternative to the field "algorithm". To be able to describe a scenario adequately, we define two more new fields: "mode" and "name". In the mode field we offer a selection of the values "problem", solution", "interac-tive", and "guidedTour". These values can be used by a teacher to define the degree of interactivity he wants to assign to a resource. The name field stores the name of the respective sce-nario. The field "scenario" can then store choices of the things a smart LO can explain. The items of the lists can have a differ-ent degree of interactivity.

- *InputData*:
  A very important new field with regard to dynamic metadata is the field "InputData". Regular static resources don't need any input data. Smart Learning Objects can be parameterized by input data. The same smart LO can then be used to animate dif-ferent topics. An example is given in Section 5. Input data can for example be stored in a serialized way in a file. The field "InputData" then contains the file name of the input data.
- *OutputData*:
  Like input data, a smart Learning Object can communicate with the outside world using output data which can be stored in a serialized way in a file. The field "OutputData" of the cate-gory "dynamic metadata" would then contain the name of the file.
- *Explanation*:
  Many smart multimedia learning objects come with some sort of explanation, for example a text motivating a problem, or an audio introduction explaining the screen setup, or the process-ing which is visualized in the smart LO.We propose to use a new dynamic category "explanation" with the fields "type" and "media". The type of an explanation can for example be "hints", "errors", "logs", or "information". The type "hints" can for example activate a hint narration of the topic to be visu-alized. The type "errors" could activate an error rendering of the topic to be visualized. In some cases it can be very useful to inform the user about errors which result from an incorrect use of parts of a smart LO. The type "logs" can activate a narration of the logs of a smart LO visualizing a topic which can be used to discover the history of the use of a smart LO. The type "information" can activate an explanation of the general steps of an algorithm to be visualized by a smart LO. Many animations which can be found nowadays don't use an explanation of the animation itself which makes it sometimes hard to use the animation. The field "media" contains information about the storage format of the available explanation. Possible values are "Text", "Audio", or "Video". As an example, a combina-tion of "Information" and "Audio" stored in the fields of the category "Explanation" would explain the functionality of the animation using a pre-recorded audio file.

The general structure of the dynamic metadata category extending the base LOM scheme is shown in Table 1.

No.	Property	Description	Example
1	Code Information	The information concerning the code of the smart LO	
1.1	codeName	The name of the start code of the sLO	a.class, a.flash, etc.
1.2	codeLocation	Denotes where the sLO s located	URI
1.3	codePackage	The name of the package or zip of the sLO	a.jar, a zip, etc.
2	Presentation Information	The information concerning how the smart LO is to be presented	
2.1	Language	The language, the smart Learning Object (LO) should start with.	en, de, fr, etc.
2.2	DifficultyLevel	The degree of difficulty the resource should start with.	very low, low, normal, high, very high
2.3	InteractivityLevel	The degree of interactivity of the resource.	very low, low, normal, high, very high
2.4	Dimension	The 3 dimensions Information of the visualization unit.	x,y,z
2.5	Bidirectional	Indicates whether the explanation, visualization can be done in the back direction or not.	yes, no
3	Topic Information		
3.1	Topic	The name of the topic to be shown by the resource.	Fifo, Earliest Deadline First, ..

Table 1: Proposed fields of metadata for dynamic content

3.2	Scenario	The name of the scenario to be visualized by the resource	-
3.2.1	Mode	Intention of the teacher with regard to the smart LO.	problem, solution, normal, guidedTour
3.2.2	Name	Stores the name of a scenario.	collision, shortframe
3.3	InputData	The name of the input file needed by the resource to start properly.	parameters.txt
3.4	OutputData	The name of the output file the resource should generate.	parameters.txt
4	Explanation Information	Indicates which kind of explanation is required for a smart learning object.	-
4.1	Type	A list of possible explanation types.	Information, warning, error, log, hint
4.2	Media	A list of possible media types to be used for the explanation	Text, audio, video

Table 1: Proposed fields of metadata for dynamic content

It should again be noted that the LOM base scheme already introduced some fields which are similar to the ones described above. An example is the field "language". These fields are however not well suited to describe the special abilities of smart multimedia Learning Objects.

5. TOOLS AND APPLICATION OF DYNAMIC METADATA

Figure 2 shows the overall architecture of our smart Learning Object tagging and customizing architecture. Learning resources are tagged using the xLOM editor described in Section 5.1. For the storage of static and dynamic metadata we use a relational database. In our implementation we used both Microsoft Access and Oracle databases.

We also implemented a tool to customize interactive visualizations with the use of dynamic metadata. We call this tool, which is described in more detail in Section 5.2, "content customizer". We use the content customizer to customize the same smart Learning Object in different ways within a lesson. We are then able to use visualizations several times in a learning unit, according to the context of the unit, which is described in detail in Section 5.2. In Figure 2, a smart Learning Object is reused in different scenarios with different metadata sets to show different scenarios of the same topic.

5.1 xLOM Editor

In the following we describe the tool that we use to create both static and dynamic metadata. The tool can also be used to publish metadata records for various resources, e.g. documents, images, audio clips, videos, animations, virtual reality worlds, or multimedia exercises.

A metadata record consists of a set of elements, describing a multimedia resource. Examples of these elements are date of creation or publication, type, author, format, or title of a resource. To access and discover multimedia information resources in a comfortable way, we developed a user-

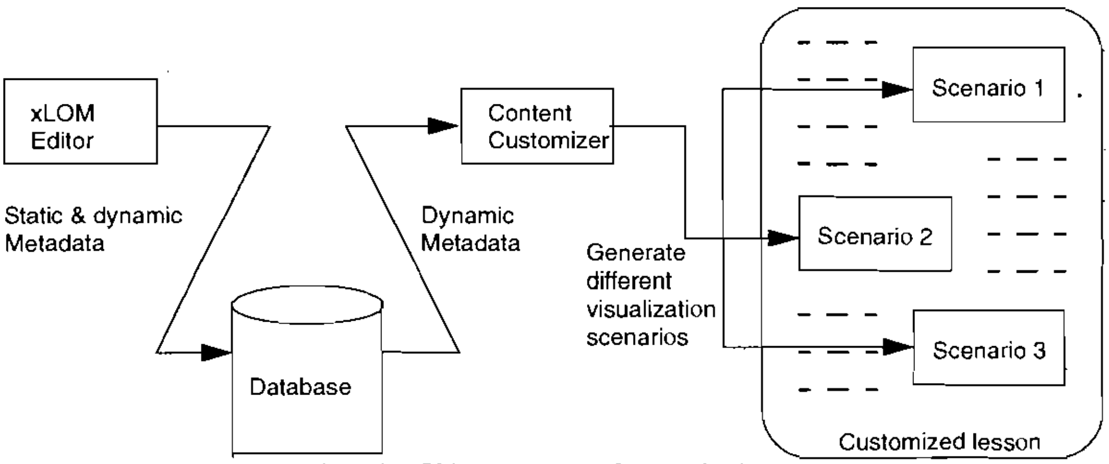

Figure 2. Smart Learning Objects tagging and customization process

friendly tool, the LOM editor, based on the IEEE-LOM scheme version 4.0. The LOM editor can be used to create and store LOM records in a relational database, and can also be used to query the database and to navigate on a resulting metadata set. When working with the editor it turned out quickly that smart LOs can only be described to a limited extent using the base LOM scheme. We extended the LOM editor to a new editor called *xLOM* (Extended LOM) *editor* by adding an extra category for dynamic metadata which has been described in Section 4.

When tagging the source material with the xLOM editor, an interesting experience turned out: Most elements of a lesson to be described apply the same basic metadata information, such as the name of the author, the rights of the lesson, or the targeted user group. It would hence be very useful to use a set of templates to tag the material. Templates can avoid the necessity to fill a lot of fields again and again, for example the owner fields, the necessary browser requirements, and many more. In our current implementation, templates are used to store information, which is then only typed in once and can be applied multiple times.

To be able to exchange metadata with other applications, we included an XML-based import/export functionality as part of the xLOM editor. This work is based on the LOM object model [1] provided by IMS.

We used the xLOM editor to tag various multimedia elements, for example the Java applets that were developed as part of the Multibook project. An example of the new functionality introduced by our xLOM scheme is the animation explaining IEEE-802.3 Ethernet [14], which will be explained in Section 5.2

5.2 Application Example

As an application example we developed a lesson explaining the protocol CSMA/CD (Ethernet). The main goal of the lesson is to demonstrate the possibilities that the parametrization of an animation offers. A German version of the lesson can be found on the web using the URL http://www.kom.e-technik.tu-darmstadt.de/projects/iteach/itbeankit/applets/paradelektion/.

In the example we first explain the functionality of Ethernet. After that the student has to answer the question which problems have to be faced in a bus-topology. We provide a set of different answers and use the same animation to explain why the answers are correct or not. The difference between the answers is explained by different parametrizations of the animation. These parametrizations are stored as dynamic metadata for smart multimedia learning objects as explained above. An example is shown in Figure 3 where the possible answer to the question is "The protocol is complex because messages cannot be sent to a specific computer, they can only be sent to several computers at once."

Another scenario of the same animation can also be used to provide an answer to the question "How can the collision problem be solved in Ethernet" if dynamic metadata are used. A possible answer to the question would be "Collisions cannot be avoided. If a collision is detected the transmission has to be repeated".

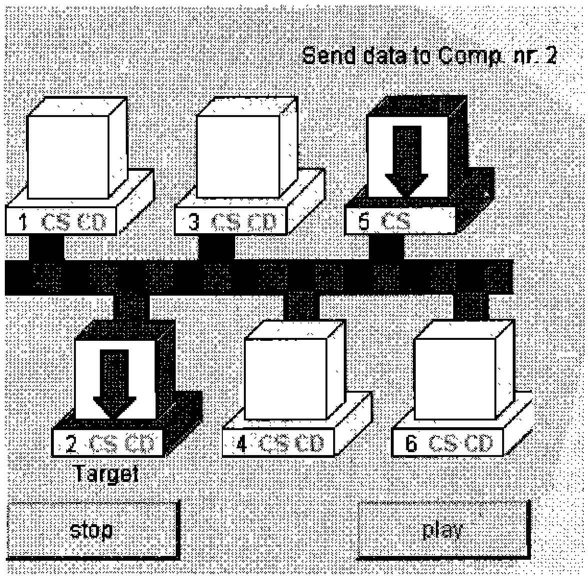

Figure 3. Example of parametrization of smart LO

A parametrized version of the same animation as shown in Figure 3 is illustrated in Figure 4. Note that due to the use of dynamic metadata the same animation is reused in a different context.

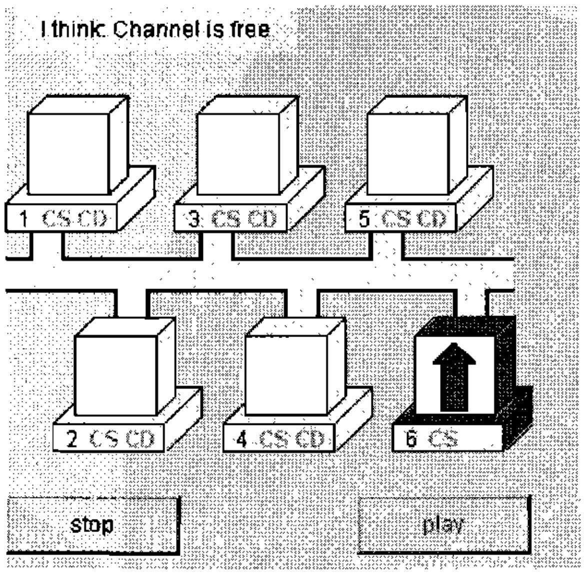

Figure 4. Second example of parametrization of smart LO

A screenshot of the lesson is shown in Figure 5.

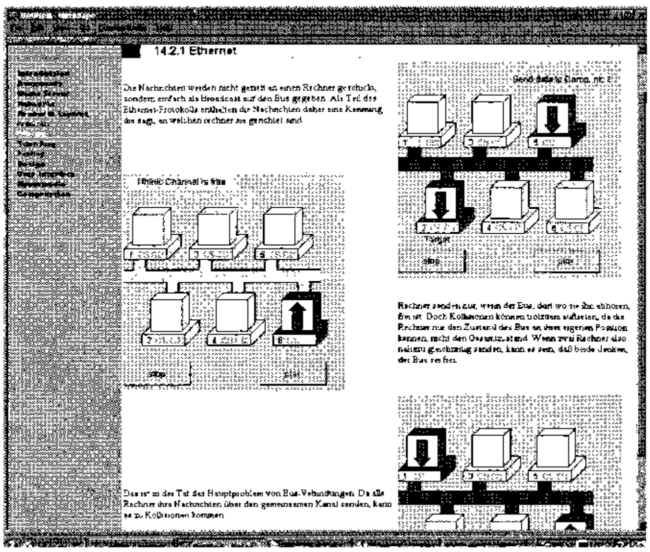

Figure 5. Screenshot of example lesson

6. CONCLUSIONS AND OUTLOOK

In this paper, we introduced an extension of IEEE's Learning Objects Metadata, to be able to describe dynamic multimedia learning objects to which we refer to as *smart multimedia learning objects*. Traditional metadata to describe learning objects are well suited to describe static elements (for example texts, or images), but do not take into account the dynamic nature of multimedia elements (especially animations and multimedia presentations).

The metadata-based framework presented in our paper also addresses the customization of smart learning objects by metadata. Having explained the necessary category of dynamic metadata, we showed our implementation of the tools which can be used for tagging, storing, and customizing smart Learning Objects. As a prototype, we implemented visualization artifacts dealing with the network protocol "CSMA/CD (Ethernet)". The implementation is also available on the web: http://www.kom.e-technik.tu-darmstadt.de/projects/iteach/itbeankit/applets/paradelektion/. We are currently using our framework to develop other examples of teaching animations for our multimedia and communications courses, for example animations to explain multimedia scheduling algorithms.

In our future work we aim at extending our framework by powerful tools to define templates for tagging purposes, as well as by a comfortable XML import/export functionality to facilitate the data exchange with other learning systems.

The main concern of our paper is not the precise way the data structures are set up to define metadata for dynamic learning objects. It is our main goal to start a discussion with regard to multimedia learning objects and thus to find an optimal solution to address issues related to metadata for multimedia smart learning objects.

7. ACKNOWLEDGEMENTS

The authors would like to thank the Bundesministerium für Bildung, Wissenschaft, Forschung und Technologie (BMBF) and the Volkswagen Stiftung which partially funded the research project.

8. REFERENCES

[1] *Instructional Management Systems* (IMS), http://www.imsproject.org

[2] *Learning Technology Standards Committee* (LTSC), http://ltsc.ieee.org

[3] *Multibook*, http://www.multibook.de

[4] Steinacker A. , Seeberg C., Reichenberger K. , Fischer K., and Steinmetz R.. *Dynamically Generated Tables of Contents as Guided Tours in Adaptive Hypermedia Systems*. In Proceedings of the EdMedia & EdTelecom, June 1999.

[5] Fischer S. and Steinmetz R. *Automatic Creation of Exercises in Adaptive Hypermedia Learning Systems.* In Proceedings of 10th ACM conference on Hypertext (HT'00, to appear).

[6] El Saddik A, Fischer, and Ralf Steinmetz. *ITBeankit: An Educational Middleware Framework for Bridging Software Technology and Education.* In Proceedings of EdMedia 2000. 26. June - 01 July 2000, Montreal, Canada.

[7] El Saddik A., Seeberg C., Steinacker A., Reichenberger K., Fischer S., and Steinmetz R. *A Component-based Construction Kit for Algorithmic Visualizations.* In Proceedings of the Integrated Design & Process Technology "IDPT'99, June 1999. will appear in the IDPT 2000 proceedings.

[8] Steinmetz R. and Nahrstedt K. *Multimedia computing, communications, and applications.* Prentice Hall, 1995.

[9] Böhm K. and Rakow T. *Metadata for Multimedia Documents.* In Metadata for Digital Media, Special issue of SIGMOD record, 23 (4), ACM Press, December 1994.

[10] *Provisional Report of the Dublin Core Subelement Working Group*, http://purl.oclc.org/metadata/dublin_core/wsubelementdrafts.html

[11] IEEE Learning Technology Standards Committee (LTSC) IEEE P1484.12 *Learning Objects Metadata* Working Group http://ltsc.ieee.org/wg12/

[12] *Alliance of Remote Instructional Authoring and Distribution Networks for Europe*, ARIADNE. Project of European Union, Website http://ariadne.unil.ch

[13] *Educom's Instructional Management Systems Project* (IMS), Website http://www.imsproject.org

[14] ANSI/IEEE standard IEEE-802.3: Ethernet.

[15] Lagoze C. *The Warwick Framework, A Container Architecture for Diverse Sets of Metadata.* D-Lib Magazine, July/August 1996, and http://www.dlib.org/dlib/july96/lagoze/07lagoze.html

[16] *Resource Description Framework* (RDF), http://www.w3.org/RDF/