EDUCATIONAL CONTENT MANAGEMENT

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Abstract: In the present paper we discuss aspects and opportunities of educational content management, focusing on structuring and interactivity schemes from semantic notions of components. A transition from standard educational annotations to semantic statements of hyperlinks is discussed. We introduce the Hypermedia Learning Object System hylOs, an online learning system. hylOs is based on a cellular information model, encapsulating content with meta data conforming to the Learning Object Meta data (LOM) standard. Content management is provisioned on this semantic meta data level and allows for variable, dynamically adaptable access structures. Context aware multifunctional links, based on the semantic linking scheme, permit a systematic navigation depending on the learners and didactic needs, thereby exploring the capabilities of the semantic web. hylOs is built upon the more general Multimedia Information Repository (MIR) and the MIR adaptive context linking environment (MIRaCLE), its linking extension. MIR is an open system supporting the standards XML, Corba and JNDI as well as high-level authoring tools for the creation of meta data and WYSIWYG like content editing.

Key words: Content management, meta data, authoring tools, open hypermedia system, semantic educational web, adaptive learning environment, link semantic

1. INTRODUCTION

In recent times tele-learning applications are increasingly requested to provide self-consistent online lectures to students at the university level. Online educational applications as well as their content modules are drawn away from carrying instructional knowledge of well defined simple tasks. Instead, they need to cope with the wide range of complexity and interrelations, university course teaching brings along.

The quality of online learning applications mainly depends on two ingredients: The content itself and its presentation, the latter including hypermedia elements of interactivity. Today's ease in presenting multimedia and hypermedia content on the net leads us to disregard that casually designed learning material in hypermedia appears particularly incoherent, nonsignificant and disappointing to the student (Landow, 1989).

Well prepared and maintained electronic content and its management in open distant learning faces a diversity of extra demands, among them

– coherence and timeliness of information
– re-use of simple, compound and fragmented content material
– dynamic content structuring and arrangement with coherent presentation
– ease in authoring and updating of content constituents
– flexible options of content decoration with meta data
– semantically guided content access and retrieval.

All of those demands urge the need to overcome simplistically linked HTML content pages.

Particular attention needs to be drawn to the way linking is done within an application. Since "simply linking one text to another fails to achieve the expected benefit of hypermedia and can even alienate the user" (Landow, 1989), a coherent, transparent rhetoric scheme of setting hypermedia links within content units should be applied.

Any of those demands cannot be easily achieved or reached at all manually and should be supported by an educational content management system. Most of the above features, however, remain unseen in current learning environments. The primary, most often violated fundamental principle for educational content management we see in the strict separation of structure, logic, content and design, as it can be achieved by applying XML-technologies (XML, 2004) in a rigorous fashion. Here it should be noted that hyperlinks in our view belong to structural information and therefore must not be stored within content.

The view of content presented to the students should be seen as part of the didactical model. Thus its arrangements need to remain open to the teaching and learning process. The generation of views in general include the provision of navigational and link structuring, of rhetorical and narrative devices as the result of dynamical meta content processing, personalisation capabilities and the system ability to adapt to personal requirements. As these are elements of the didactical concepts, all properties of the views need to remain subject to flexible configuration and modelling. Flexibility though ends where the author is driven towards the revocation of presentational concepts, as it is likely for manually encoded pages. The modelling therefore should be located on a separate layer, effective to the entire application. Only thereby a coherent view to the learner can be ensured.

This report concentrates on our project activities of modelling and implementation of an educational content management system, which supports most of the above mentioned requirements. Our work covers concepts and implementation of organising and retrieving content and its meta data, modelling static and dynamic (hyper-) structures, authoring and viewing content pages in a context sensitive fashion. Our immediate practical application forms the Hypermedia Learning Object System hylOs (Engelhardt, Schmidt et. al., 2004), which we will introduce along the lines of this article. The management of our university's website fhtw.web as a high-level information system is also done within our described framework.

The field of educational hypermedia systems, though quite old, continues to show very active research and development activities resulting in numerous concepts, technologies and platforms presently under work. Our work ranks around XML formats and technologies and relies on the more general storage and runtime platform Multimedia Information Repository MIR (Karpati, Rack and Schmidt, 2004). Built on a three-tiered architecture, MIR provides all fundamental support of media data handling, authentication, user and connection handling. MIR is built as an open system and currently supports the standards XML, Corba and JNDI.

Grounded on a powerful media object model MIR was designed as a universal fundament for an easy design of complex multimedia applications. By means of it's fully object oriented design MIR attains parametrisable, flexible data structures, thereby offers re-usability of content objects at any level of complexity. A generic, only type dependent editing of data is part of the system, as well. MIR provides two layers of structuring content components, both open to application semantics: A passive referencing interrelates any entities according to static application structures, active references are composition mechanisms evaluated at runtime. These active interrelations not only refer to subordinate presentation data, but also are capable of imposing event-type actions on its references. For further reading we refer to (Feustel et al, 2001) and (Feustel and Schmidt, 2001).

This paper is organised as follows: In the subsequent section we discuss major problems and concerns educational hypermedia content organisation and introduce the basic building blocks of our work. Section 3 is dedicated to the shaping and processing of eLearning Objects (eLOs) and their practical use. Along the lines we will present a short overview of our Hypermedia Learning Object System, placing special focus on content access and eLO authoring. The more intricate aspects of a semantic representation of eLOs and their implementations are presented in section 4, meeting our more general results of a semantic theory of hyper references. Finally section 5 will draw conclusions.

2. BUILDING CONTENT FROM CELLS

2.1 Educational Content

Building educational content significantly depends on the target media: In writing a book we create an unchangeable, monolithic block of strict linear order. Setting up a collection of HTML documents results in a mesh of easily changeable content elements, which show a strict page orientation. The relational mesh itself, when fixed with the rather rigid HTML linking scheme, withstands any seamless modification. Most of the learning platform environments on the market today follow the latter framework, thereby inheriting its severe shortcomings. Authors and readers thus are forced to cope with material inherently shaped by the publication method.

The early days of hypertext already brought up alternative ideas of online content forms: Self-consistent information objects, possibly composed of several connected components, should serve as input for runtime environments more elaborate than today's browsers (Hall et al., 1996). Information fragments were foreseen to be loosely coupled by relational hyper reference components, offering impressive flexibility and the perspective of augmented interpretation. Retrospectively examined, such pioneer work as the Dexter Model (Halasz and Schwartz, 1994) required complementation by three major steps: The notion of context had to be introduced at the conceptional level. Presentation independent encoding techniques were needed for content and hyperlinks. Finally, definitions of structural standards for information encoding had to be invented.

In education the latter task has been addressed lately with the emerging standards Learning Object Meta data (LOM, IEEE 2002) and Sharable Content Object Reference Model (SCORM, Dodds and Thropp, 2004). LOM introduces an annotation hierarchy of meta data of intermediate complexity, but also the notion of learning objects as a collection of content components conjoint with its meta data. LOM's eLearning Objects (eLOs) revitalise the idea of rich, coherent information entities, subject to an appropriate processing for presentation. LOM itself forms one ingredient of the fairly comprehensive SCORM concept, which lacks practicability due to its normative implementation instructions of inferior technical kind.

Building educational content using eLOs instead of pages opens up a variety of fascinating new opportunities for authors, teachers and learners. Concurrently this concept imposes specific restrictions and open questions, which are currently under lively discussion (Wiley, 2000). On the one hand variable content access paths and online views may be generated from the same collection of re-usable components, individually adapted to specific contexts of teachers and learners. On the other hand authors need to provide the required meta data and have to cope with the complexity of breaking content into self consistent units. In such granular concepts both authors and readers may have to struggle with identifying a coherent train of thought.

2.2 Hypermedia Content Organisation

Automated processing of hypermedia content relies on strong structures. They can be implemented in two ways: Information material on the one hand may be decomposed into many small entities on the component layer. A text, for example, could be split over many files. On the other hand structuring can take place on the within-component layer by means of a sub-addressing scheme. The text within one file, for example, may be built according to a DOM tree. The major difference of the two approaches is reflected in the data access. Either a file system or database has to be searched for appropriate content constituents, or a mime type dependent retrieval of fragments has to be performed within data units. The latter could be of Xpointer-type in text/XML documents, a frame addressing in video/audio data, a polygonal geometry allocation for images, etc. For a more detailed discussion on fragmenting see (Grosso and Veillard, 2001).

Fragment addressing is much more complex and, from a computational point of view, expensive operation than component retrieval. On the other hand viewing and authoring of information entities consisting of many components is rather complicated. Being aware of these two extremes our cellular approach of content organisation forms a compromise: Text content of our solution is assembled from cells, where cells are addressable elements consisting of an unstructured word at minimal and a text paragraph at most. The paragraph itself may be sub-structured according to its XML schema.

In detail our content modelling proceeds as follows: All autonomous information s.a. titles, authors, keywords, or information about courses etc. are singled out. Separating these entities not only reaches for a high level of normalisation, but also easily permits automatic generation and updates. All other content units are organised in paragraphs which are collected to pages by means of external structures. Note that page editing thereby mainly arranges paragraphs. Through this concept entities of paragraph dimension are easily re-used by applying multiple structural references in a static or dynamic way. Note also that meta annotations may be kept paragraph-wise, as this can be necessary for microscopic didactical concepts.

2.3 The Requirement for Context

When formulating an abstract, flexibly meshed storage layer, the Dexter group made a fundamental conceptional mistake. As was pointed out in the

Amsterdam Hypermedia Model (Hardman et al, 1994), the concept of composites is incomplete without the notion of context for its components.

Context is an inevitable part of the information needed for processing hypermedia. In HTML it is implicitly encoded via the embedding of links and anchors. In general there are two context situations to consider: The context of source or departure and the context of destination or arrival. In formal terms, the context of a component is denoted by the data immediately embedding it. This notion of context generalises to fragments, as well.

While building content from composite components, context needs some kind of extra encoding. This could be done by maintaining an additional information layer as is the ‘perspective’ approach in the Nested Context Model of Soares et al (1995). Their fairly general concept suffers from the drawback of carrying an additional, partly redundant data structure. In (Hardman et al, 1994) it has been already noted that content structures are suitable for carrying context information. Note, though, that context cannot be expressed by positioning components within a hierarchical file system, as it is often attempted in traditional web server organisation: Object re-use and non-hierarchical component relations contradict a one-to-one correspondence of application contexts and a file system view.

However, context is implicitly encoded within the composite structure of the application. Accessing a component along the way of its currently valid composite references is equivalent to reconstructing its actual context. Starting from this observation, we introduce the concept of *context-sensitive* or *semantic paths* (Engelhardt et al, 2002). Semantic paths are built of named relations within the composite structure, which can be seen as directories combined with an appropriate access and retrieval logic. Applying these semantic paths the content appears as if organised in a file system, which is neither hierarchical nor normalised. Possible recursions thereby need to be treated by the access logic. Seen from the supported JNDI interface, semantic paths simply form an alternate name space. Note that this semantic name space can be easily inverted to visualise the relation of ‘Who references this component?’.

3. THE HYPERMEDIA LEARNING OBJECT SYSTEM HYLOS

3.1 Managing ELO Content

In this section we want to introduce hylOs, our model and prototypic implementation of an educational content management, solely built on eLearning Objects. Operating on a base of eLOs, hylOs pre-processes content for variable views: Each component can be displayed as comprehensive slide or detailed descriptive information. According to LOM attributes the learner may personally adjust learning complexity, context and the semantic density of all presentations. Different access structures are provided according to the didactic model in use. Fig. 1 shows a hierarchical overview, a predefined instruction path representing a behaviouristic approach, and adaptable access tools in constructivist fashion for searching and navigating the textual relations interactively. The learner is aided by overviews on completeness. HTML and PDF currently are supported as presentation formats, where other kinds of preparation may be added easily.

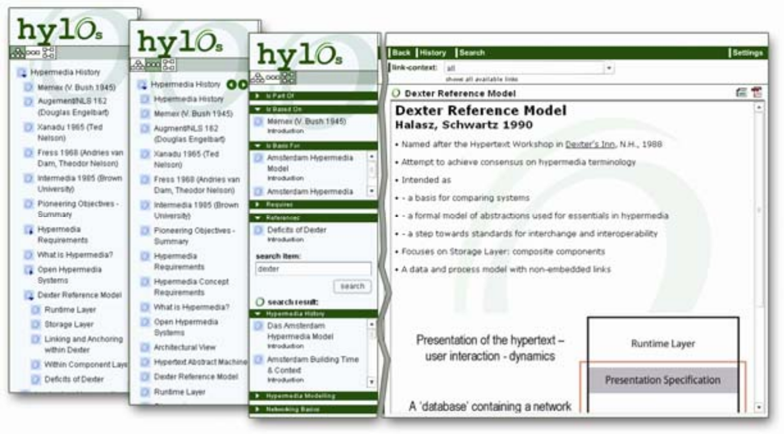

Figure 1. Three content access views within hylOs.

Hyper referential relations within these applications are adaptable by authors as well as by users on a semantic layer. In hylOs an author can define contexts of hyperlinks, representing the rhetoric of his choices. Learners may opt for the link context in use for their navigation. These capabilities are the outcome of the MIR adaptive Context Linking Environment described below, which is part of hypermedia learning system.

As proposed by the LOM standard eLOs in our system are simultaneously formed from content entities and meta descriptors. Content is built from XML paragraph objects, as is the standard cellular content concept within the underlying MIR system. Additional information such as taxonomies according to external categorisation schemes, e.g. DDC, glossaries, bibliographies or organisational data have been modelled within the system and become accessible to eLOs by reference identifiers.

hylOs foresees an import and export of content packages, following an attempt to implement SCORM Content Aggregation Model and Content Packaging. Meta data and relations of Sharable Content Objects are encoded according to the standard, content itself remains in its original, higher valued XML format. Not included is any encoding of Sequencing and Presentation.

3.2 Efficient eLO Authoring

Authoring Learning Objects is not a simple task: Content has to be comprehensively shaped for covering a single, self-consistent subject. Meta data, to some extend, are inevitably needed. It is a necessary but ambitious challenge, to provide an authoring tool for seamless production of eLOs.

The hylOs eLO editor (s. fig. 2) allows for a coherent authoring of complete learning objects, i.e. content, meta data and referential relations can be developed within *one* application. The tool attains three main views: The content navigator, the content editor and the meta data builder.

The **content navigator** offers the traversal and modification of eLO structures, operating on the relational context paths described above. Note that, as the applicative eLO structure need not be hierarchical, the generated view of an object tree forms a non-normalised representation of the content.

The **content editor** is dedicated to the production of the entire content, i.e. descriptive paragraphs and slides. The main information structure to be filled is the XML-formatted free text paragraph (including images or other media) and their descriptive elements s.a. title, headwords and sectional titles. The latter strings are recycled to automatically generate a ‘standard’ slide for every eLO - a ‘quick and simple’ slide production. For voluntary use hylOs offers an unrestricted slide presentation layer, to be correspondingly authored by the XML paragraph editor.

To tackle the XML authoring problem we designed an editor toolbox on the basis of JAVA/Swing, which dynamically adapts to the specific formatting requirements of content components. A WYSIWYG XML word processor for editing paragraphs is part of the tool set. As offering a WYSIWYG MS-Word-like editor for writing continuous text appears to be the only approach widely acceptable to the user, we mapped the structural elements of XML to common layout elements on the screen, thereby simulating an average type style sheet. Since XML structuring is by no means congruent to formatting of text, this is a conceptual incorrectness, which we try to alleviate by displaying the structural entity on mouse-over.

The **meta data builder** takes care of generating the eLO meta data set with minimised authoring effort. Required specifications are arranged on *one* sheet, where obligatory data are reduced to *seven* fields at the upper part (s. fig. 2). The acquisition of meta data is essentially done in three ways:

Automatic Generation for most of the LOM attributes: All technical data (author, formats, sizes, dates, aggregationLevel …) are directly provided by the MIR system. The content title is used as the LOM title, the sectional titles as coverage fields and as a description the (reformatted) first content paragraph. An additional set of faintly fluctuating data, e.g. language or intendedEndUserRole, are taken from user specific presets.

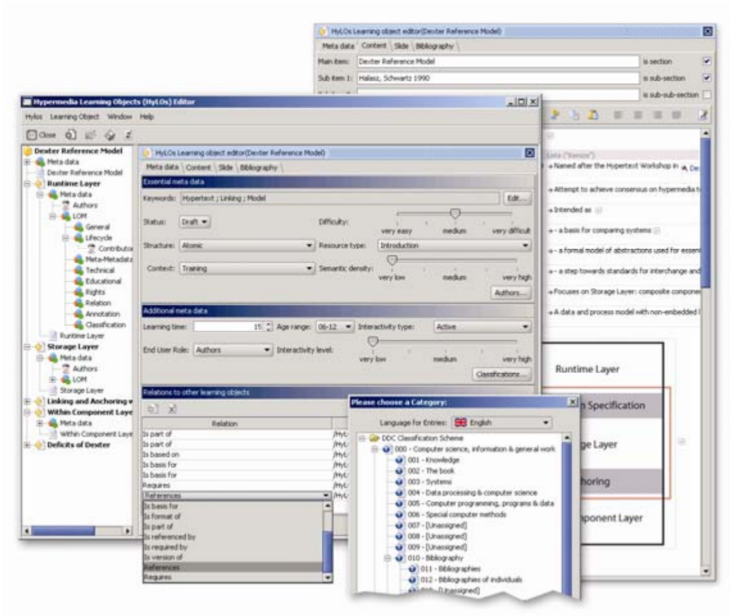

Figure 2. Authoring eLOs within hylOs.

Obligatory manual provision for seven LOM attributes: Keywords, semanticDensity, difficulty, context, learningResourceType, structure and documentStatus require editing, if formerly learned presets do not apply.

Facultative manual provision for the remaining LOM attributes may be added either on the front sheet or by accessing the complete meta data tree.

Additional information structures s.a. glossary entries, taxonomic classifications or bibliography entries are accessible within the editor. Thus an author of eLOs is enabled to create or manipulate complex objects without distracting his concentration from content.

4. AN ADAPTIVE LINKING ENVIRONMENT

4.1 Identifying the Semantic of Hyperlinks

Assuming LOM metadata at content items in presence, a canonical semantic description is easily derived: Using RDF (RDF, 2004) presentation the content object attains the role of the subject, the name of the meta descriptor forms the predicate and the value of it denotes the object. For example a LOM general description “about hamster diseases” turns into the statement “this learning object is a description about hamster diseases”.

To approach a semantic analysis of hyper referential links, let us recall that a hyper reference is constructed of two entities, anchors and links. Links concatenate anchors, which identify sub portions of content. In a fairly general fashion anchors can be expressed within XLink statements by XPointer/XPath-like expressions (XML, 2004), the exact formalism depending on the media type of the document. Links as well as anchors may be stored separated from document resources, e.g. in a link base.

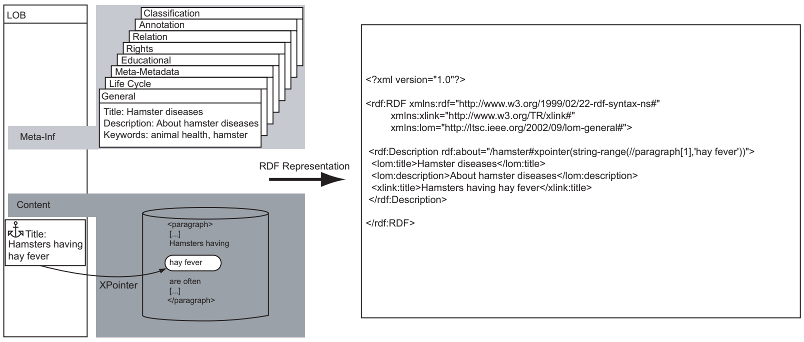

Figure 3. The gain of additional anchor descriptors.

Even though it appears rather straight forward that a semantic description of an anchor should inherit the expository statements of the underlying content, sole information inheritance remains insufficient, since a document in general may carry several, sub specific anchors. It is therefore important to provide additional specifications as can be done by the title and label tags inherent with XLink locator expressions. Note that data chunks in anchors need not be of textual type. Anchors in this sense must be viewed as specialisations, i.e. “this resource in the context of hamster diseases carries the title of hamsters having hay fever”. The extraction of a semantic description as a collection of inherited and dedicated statements visualises fig. 3.

Links denote relations between two or more anchors. They are directional components, uni- or bi-directional. Following the XLink arc encoding a link expression itself may carry directionless attributes, multiple *titles*, as well as directed descriptors, e.g. the *arc* attributes *from*, *to* and *arcrole*. A semantic of hyperlinks naturally should build up on attribute matches, i.e. using *arcroles* whenever *arc* and direction apply, and on the linked resources. This gives rise to a collection of simple statements: “This link carries the title ‘For freshman’“, “This link starts at the resource ‘hamster having hay fever’”, etc.

In semantic terms statements represent linked resources. A link encodes a relation between them, which is directionally attributed by means of the arcrole. Thus at second an XLink expression gives rise to a more complex, reifying statement. A link expresses via its arcrole attribute a predicate describing the referred resources. However, in transforming this notion into a simple statement, the link resource itself remains unseen.

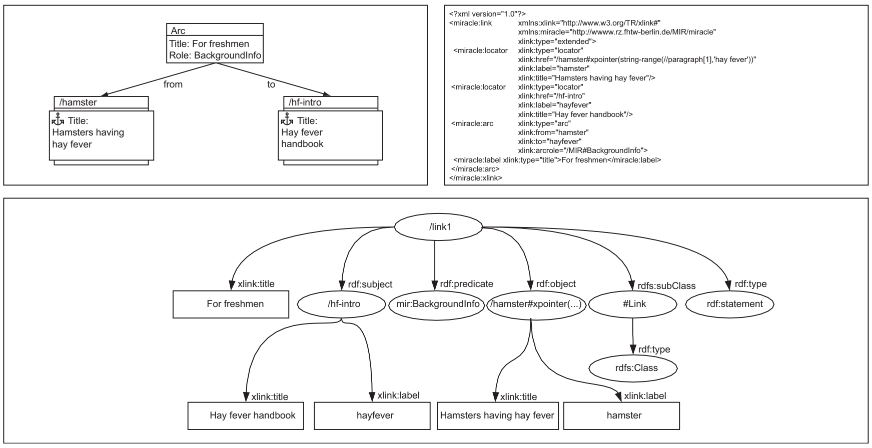

Figure 4. Gaining an RDF hyperlink description from XLink.

To cure this deficit a higher order statement, a statement about statements, needs to be used. Following this approach, the link entity forms the subject for a statement about this relation description statement. As is visualised in figure 4 such expression reads, “Link1 denotes that resource ‘Hay fever handbook’ presents BackgroundInfo to resource ‘Hamsters having hay fever’”.

Expressing the core semantics of hyperlinks as higher order statements opens the opportunity to preserve the relation to contextual information s. a. link titles etc. Viewing the approach in a rigorous semantic fashion, it is indeed correct, as a link may form a resource external to content, its denoted relation being not true by itself, but an expression of contextual and personal view of the (link) author, who may be distinguished from content authors. For further reading we refer to (Engelhardt and Schmidt, 2003).

4.2 Semantic Link Context

Connecting distributed knowledge resources is more than simply adding a link to a document. Having derived a semantic notion of annotated content, anchors and hyperlinks in the previous section we are now able to define a high-level scheme for collecting and processing links from a link-base.

In hypermedia processing the context is an important concept. There are different contexts to recognise: The context of appearance or presentation of a document, the context of document fragments, given by its surrounding document data, and the context of a hyper reference. The latter decomposes into the source and destination context of a link, which more or less coincides with the context of the anchor fragments, and the context of the linking entity as discussed above.

In the present paper we are concerned with this semantically relevant link context. Link contexts are capable of articulating certain orthogonal information such as the author, the view or the proposed application of a hyper relation. To exploit these additional encodings, a high-level semantic selection layer is needed to perform operations on link selections and collections based on the link context. Providing such mechanisms will enable users to steer hyperlink appearance by semantic criteria and thus interact more precise and purposeful with a hypermedia application. There are many imaginable operations like extracting links depending on their semantic role, attributes or on the relationship with their anchors or adapt them to users within personalised hypermedia applications.

The concept of a link context layer introduces a new abstraction on link collections. Within this layer we settle descriptions about a selection scheme for links following predefined semantic rules, operating on an abstract data model provided by the link layer. Link contexts neither create new links, nor new anchors. They are only responsible for the extraction of existing links stored in a link base. Those links are characterized by their descriptive properties as shown in the previous section, which combine in a selection scheme to represent a certain semantic context.

Link contexts are the upper tier in a four layered model consisting of a data, an anchor, a linking and the link context layer. The MIR adaptive context linking environment (MIRaCLE) is both, a formal model and a practical implementation based on the MIR system. As the result a "semantic filtering" to obtain the appropriate subset of links is applicable. All entities, anchors, links and the activated link contexts are processed on the fly as content gets observed through a standard Web browser.

As shown before, all semantically relevant notions from the link or anchoring layer are expressible in a formal RDF model. The link context itself is operating on the model of the link layer representation and enables users to select groups of semantically related links. Retrieving links means picking sub-graphs from the model. The extraction of sub-graphs could be done by an appropriate query language, like RDQL (Miller et al, 2002).

The result of such a query are statements, which have the chosen links as subject and at least one predicate object pair formed by the involved anchors and their relationship. Identifying the subject of the return statements as a link, gives all necessary information for further processing. An application could extract the participating anchors, verify them for being a start resource regarding the current document and visualize them, if wanted.

```
<?xml version="1.0"?>
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
xmlns:mir="http://www.rz.fhtw-berlin.de/MIR"
xmlns:dc="http://purl.org/dc/elements/1.1/">
<rdf:Description rdf:about="link-context1">
<dc:Creator>Mr. X</dc:Creator>
<dc:Title xmL:lang="en">Background Information</dc:Title>
<dc:Description xml:lang="en">Some continuative information on.
  </dc:Description>
<mir:link-context>
<![CDATA[
SELECT * WHERE (?link, <rdf:predicate>, <mir:BackgroundInfo>) USING
rdf FOR <http://www.w3.org/1999/02/22-rdf-syntax-ns#>,
mir FOR <http://www.rz.fhtw-berlin.de/MIR#>
]]>
</mir:link-context>
</rdf:Description>
```

Figure 5. An example of a link context definition.

Thinking in our example on a vet student reading the text about hamster diseases let us imagine a context, which selects links providing some background information on the current topic like for example “Hamsters having hay fever”. One possible link context definition is given by figure 5.

The query will return all matching nodes in the graph which are the subjects of the associated RDF statements. The subjects will contain the name of the appropriate link and a statement about the connected anchors.

In the terms of our example it will return the link which expresses: “Link1 denotes that resource ‘Hay fever handbook’ presents BackgroundInfo to resource ‘Hamsters having hay fever’”. This higher order statement contains a simple statement embedding the target anchor as the subject, the predicate being the relation and the source anchor the object. There is all necessary information for rendering the link into the document.

5. CONCLUSIONS

Teaching and learning based on hypermedia applications still is a qualitative challenge to the community. In this paper we presented a semantic approach to educational content management based on LOM eLearning Objects. New, dynamic concepts in both, navigational access intelligence and hyper referential processing have been developed for the hylOs learning application. Along the lines of this project, handsome tools for authors emerged, to ease the crucial effort of content production.

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