The Hypermedia Learning Object System

Exploiting Learning Objects In A Semantic Educational Web

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Abstract

While eLearning systems become more and more popular in daily education, available applications lack opportunities to structure, annotate and manage their contents, as well as their interactive components in a high-level fashion. General efforts to improve these deficits are taken by initiatives to define rich meta data sets and a semantic web layer.

In the present paper we discuss aspects and opportunities of gaining structuring and interactivity schemes from semantic notions of components along the Hypermedia Learning Objects System (HyLOs) our prototypical implementation of an eLearning content management system. A transition from standard educational annotation to semantic statements of hyperlinks is discussed. Further on we introduce the concept of semantic link contexts as an approach to manage a coherent rhetoric of linking. A practical implementation is introduced, as well.

Furthermore we will discuss the opportunities and benefits from using eLearning Objects (eLOs) as a base entity for both meta data and content. HyLOs is based on a cellular eLO information model encapsulating meta data conforming to the LOM standard. Content management is provisioned on this semantic meta data level and allows for dynamically adaptable access structures and reuse of cellular information. 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 Media 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. HyLOs benefits from manageable information structures, sophisticated access logic and high-level authoring tools like the eLO editor responsible for the semi-manual creation of meta data and WYSIWYG like content editing allowing for rapid distributed content development.

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1 Introduction

eLearning systems open up new perspectives on knowledge transfer. Providing valuable content and elaborate interactivity structures could encourage the learner to discover knowledge on one's own initiative in a constructivist fashion. Applying semantic web technologies to eLearning systems will facilitate a new generation of eLearning systems[1]. The semantic web technologies strongly depending on standardized meta data vocabularies to retain meaningful, machine-processable entities. In the field of education the task of meta data preparation has been addressed recently with the Learning Object Metadata (LOM) standard[2]. LOM introduces the notion of learning objects as a collection of content components together with its meta data. LOM's eLearning Objects (eLOs) revitalise the idea of rich, coherent information entities, subject to an appropriate processing for presentation. Up until now applications operating eLOs in their full potentials, thereby exploring capabilities as well as shortcomings of the model, are rarely seen.

In the present paper we introduce our prototypic solution of an eLO based open hypermedia system, the Hypermedia Learning Object System HyLOs [3], donating special focus to its variable content access options. A self-explorative content navigator following a constructivist approach is part of the system, as well as an efficient authoring tool for eLOs.

This paper is organized as follows. In section 2 we are starting a discussion around meta data acquisition being the basis for advanced eLO processing. In the 2nd part of section 2 we introduce a translational scheme of metadata decorated content into semantic statements, including a representation of hyperlinks and a semantic link selection layer based on it. The 3rd part is dedicated to the learners frontend showing in constructivist approach on eLearning content exploration. Finally section 3 gives a conclusion and an outlook on the ongoing work.

2 The HyLOs approach

2.1 Meta data acquisition

Several years of online learning experiments and debates have brought up a standardised container for educational content: the eLearning Objects (eLOs). eLOs denote the smallest, atomic learning units covering a single, self-consistent subject merging meta data, relations and content into one object. Having meta data and inter-object relations accessible in well-defined portions opens up new perspectives for an eLearning Runtime Environment. The LOM standard is divided into 9 major categories. The "general" section describes the learning object as a whole. All data regarding the lifecycle of the object like contributors or the history of the learning object are stored in the "lifecycle" category. The "metaMetadata" part contains a description of the meta data record itself. Technical requirements and characteristics are the content of the "technical" section. Pedagogic classifications could be characterized within the "educational" part. LOM "rights" allows for a note on intellectual property rights and usage conditions. Qualified relations to other learning objects are stored in the "relation" section. Additional comments on a specific educational use denoted into "annotation". Last the classification category describes where this learning object falls within a particular classification system. Due to the fairly complex structure of the LOM standard it is a challenging task for an authoring application to support the author in the meta data provision. Revising the LOM standard allows to subdivide the property set into three categories:

- Mandatory meta data enfolds all information which are necessary for a pedagogic classification or the description of the learning object itself. These properties are mainly from the LOM educational and general sections.
- Deductible meta data could be generated by the authoring environment inferred from the authors general context and technical information like MIME type or object size.
- Facultative meta data is regarded not to be required for an appropriate usage of the learning object.

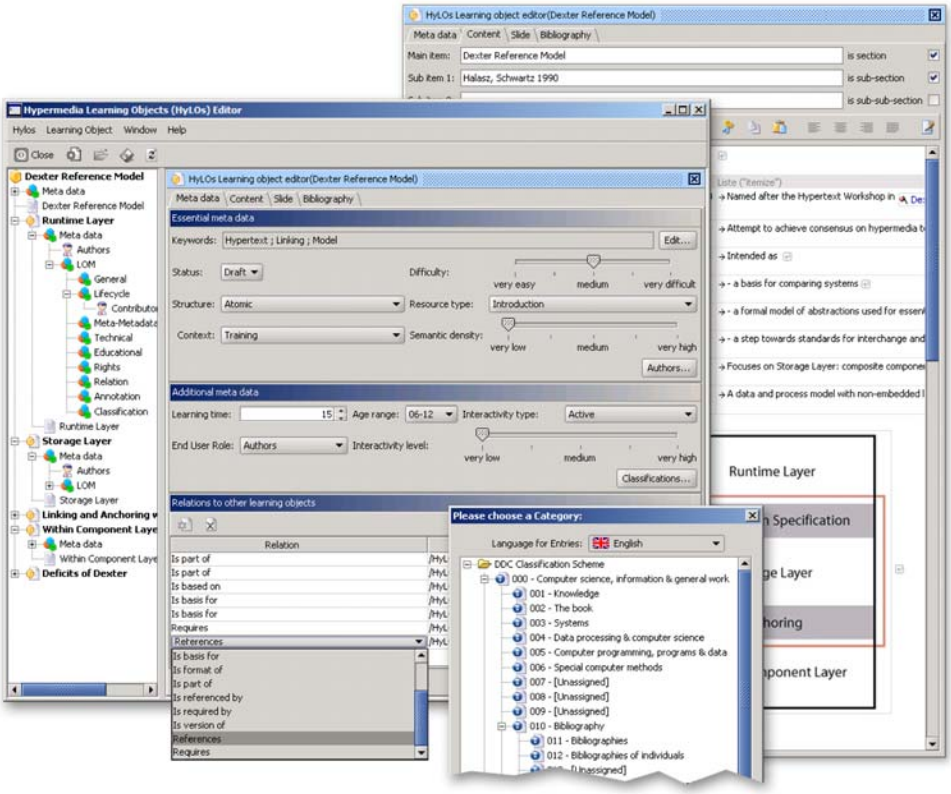

Figure 1: The HyLOs eLearning Object Editor

The HyLOs eLO editor allows for a coherent authoring of complete learning objects. Especially 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 in [4]. Note that, as the applicative ELO structure need not be hierarchical, the generated view of an object tree is in the case of object re-use 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 ParagraphContent, consisting of an XML-formatted free text paragraph (including images or other media) and descriptive elements s.a. title, headwords and sectional titles. The latter strings are recycled to automatically generate a 'standard' slide for every ELO for the 'quick and simple' slide production. For voluntary use, HyLOs offers an unrestricted slide presentation layer within the SlideContent information object, which can be correspondingly authored with the XML paragraph editor. The meta data builder takes care of generating the ELO meta data set with minimised authoring effort. Relevant manual specifications are arranged on one sheet, where obligatory data are reduced to seven fields at the upper part (s. Figure 1). 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, locations, aggregationLevel…*) are directly provided by the underlying 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.

- Obligatory manual provision for seven LOM attributes: *Keywords*, *semanticDensity*, *difficulty*, *context*, *learningResourceType*, *structure* and *documentStatus* require editing, if presets, taken from previous editing, 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, bibliography entries or persons can be accessed within the ELO editor through separate window sheets. Thus an author of ELOs is enabled to create or manipulate complex objects without distracting the focus from its destination in content.

2.2 Deriving link semantics from meta data

Assuming LOM meta data at content items in presence a canonical semantic description is easily derived: Using RDF[5] 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 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[6] statements by XPointer/XPath-like expressions [7], 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. 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". 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.

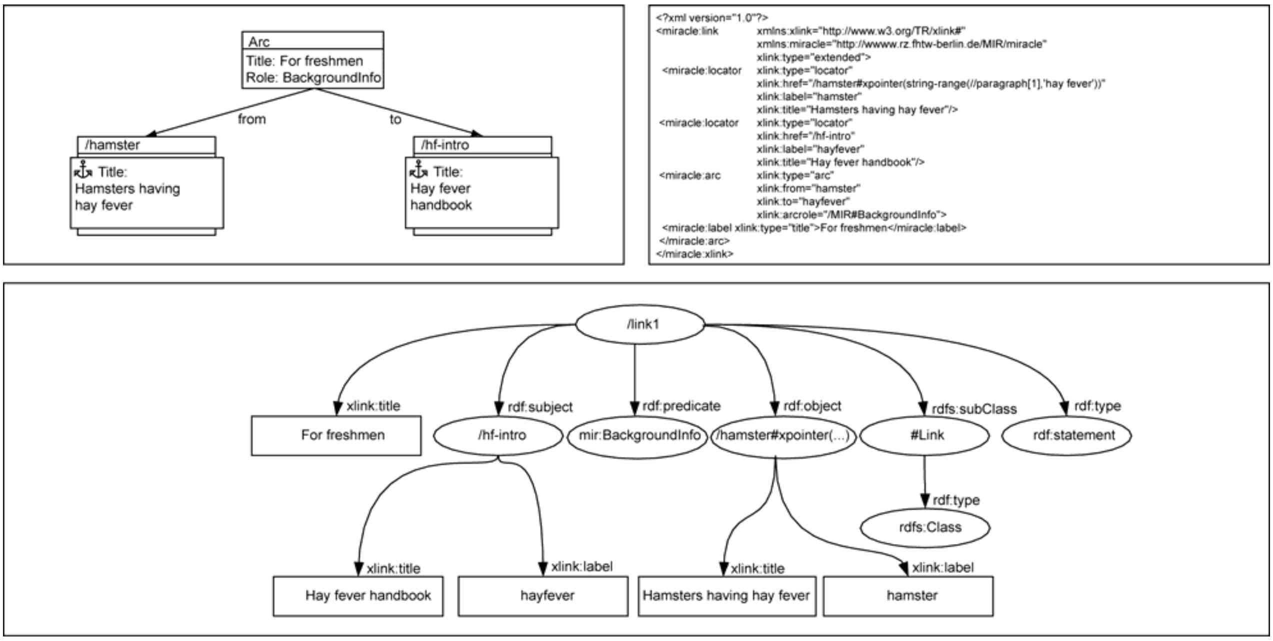

Figure 2: Gaining a RDF hyperlink description from XLink

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 2Figure 2 such expression reads, *"Link1 denotes that resource '<u>Hay fever handbook</u>' presents BackgroundInfo to resource '<u>Hamsters having hay fever</u>'"*. 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 [4].

Having derived a semantic notion of annotated content, anchors and hyperlinks 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 a document appears or is to be presented in, 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 delivered 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[8]. 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.

2.3 Building content views from meta data

Our practical implementations of the HyLOs system rank around XML formats and processing technologies. They rely on the more general storage and runtime platform Multimedia Information Repository (MIR) [9]. Grounded on a powerful media object model MIR was designed as a universal fundament for ease in modelling and implementing complex multimedia applications. All data residing in the adaptable MIR data store are published in XML format, such that individual views and user interface behaviour can be reached by lightweight style sheet programming.

Built on a three-tiered architecture MIR provides general support of media data handling, authentication, user and connection handling. Its core is formed by a media object database, implementing a duality of object oriented information model and relational structure. The system offers a free layer for application specific modelling of information and structures, the latter being twofold as passive structures and 'active' references, where traversal is accompanied by underlying code execution. A generic web authoring allows for immediate editing of the modelled information and structures. MIR is built as an open hypermedia system and currently supports the standards XML, Corba and JNDI. For further reading we refer the reader to [10] and [11].

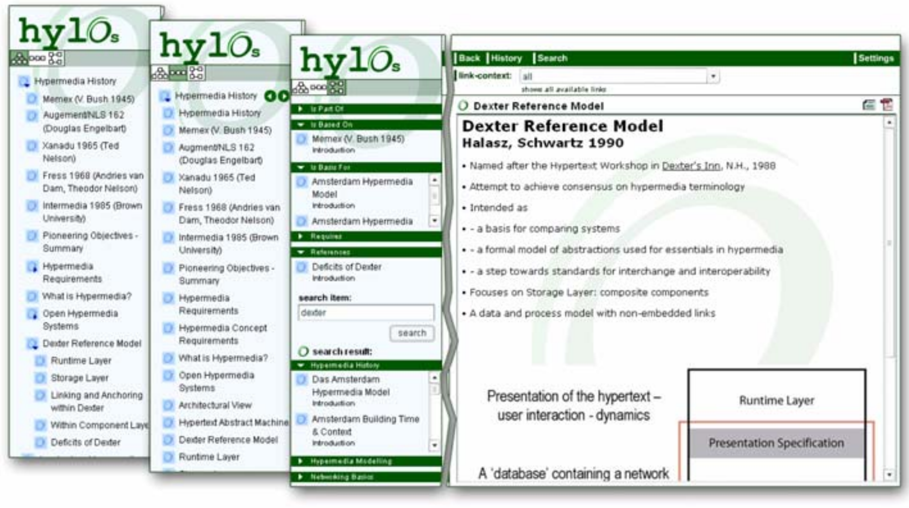

Figure 3: Three content access views within HyLOs

The HyLOs learner front-end (s. Figure 3Figure) provides three different views to the student. Each view presents the content of underlying eLOs according to a certain learning methodology. The first one is based on a linear learning paths, one instructional design as defined by a teacher. Those learning paths may be composed by choosing different eLOs from the knowledge repository. The second view is formed by the primary content structure the eLOs are embedded in. This hierarchical content organization is visualized as a tree. The root of the tree could be viewed as the most common description of the subject, whereas the leaves are the most detailed information. In contrast to the different possible path views the hierarchical presentation is unique to the content, its arrangement defined within the authoring process. The third view provides a set of constructivist tools supporting self-explorative learning. In contrast to the preceding ones which more focused on a collection of eLOs the

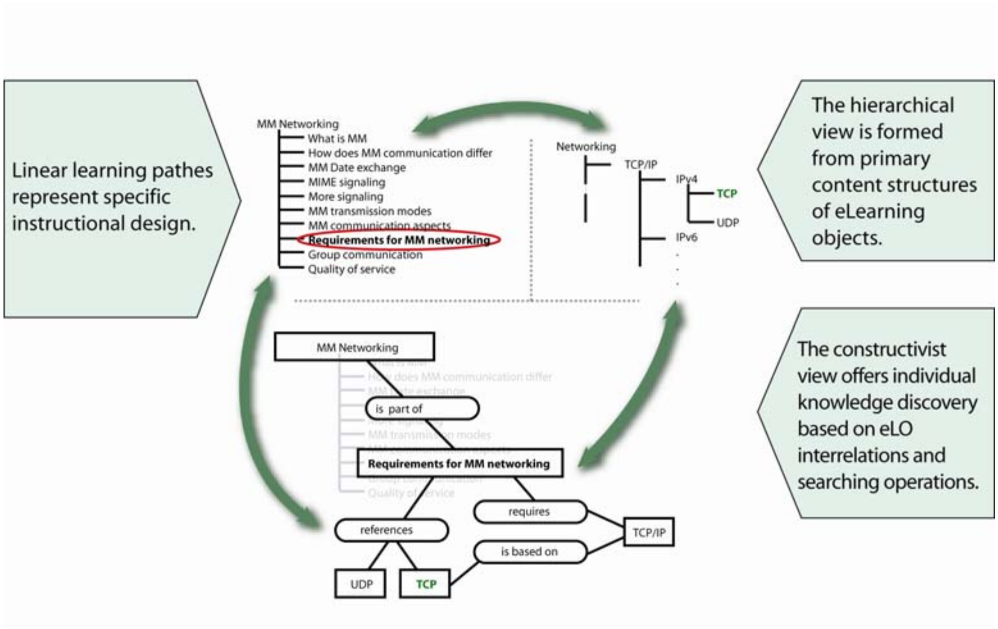

Figure 4: Use Scenarios for the HyLOs Navigator

perspective is switched to an eLO centered view. Starting from the current context node qualified relations to other eLOs are displayed. Those relations are taken from the LOM meta data “relation” section. Part of this constructivist access approach is an powerful search tool acting context sensitive across the entire repository.

To give an illustrating example (s. Figure 4) imagine a learner, a bachelor student, is working on a unit covering the issues of “Multimedia Networking” providing by his professor within an introductory class on "Networking". At some time he is reaching the subject “Quality of Service”. It introduces aspects of QoS in networking. The student is not satisfied by the introductory content given in this course and wants to acquire background knowledge. For this task he switches the perspective to the constructivist view, where related topics of his present subject (eLO) are offered. By navigating along the relations or searching for similar 'knowledge nuggets' the learner may find a new learning path called “Internet Technologies”. Here the student switches back to this newly discovered instructional path and works along this course, intended for masters students. After studying the whole QoS lecture, the student wants to know, if there is more about networking and changes to the hierarchical view. Thereby the system will show the complete structure of networking related objects of that author to him.

3 Conclusions and outlook

In this paper we present an eLO based approach on constructivist content exploration derived from well annotated, LOM conformant objects. A definition of high-level schemes for collecting and processing context aware links enables a dedicated discovery of content in a self-explorative way. Concepts and a practical solution for an open hypermedia eLO system were introduced, as well as an eLO authoring environment. Deep-in authoring and processing of learning object meta data for building new content views seems to be a promising approach for adding new interactivity schemes to eLearning applications.

Future work will concentrate on automatic content acquisition and analysis starting from records taken within lecture halls. Work also continues to make HyLOs available as a semantically aware Web service. We will investigate into semantic search and retrieval operations applying ontologies and related semantic web technologies.

Acknowledgements

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References

[1] Millard, D. E., Alani, H., Kim, S., Weal, M. J., Lewis, P., Hall, W., De Roure, D. and Shadbolt, N. (2003) Generating Adaptive Hypertext Content from the Semantic Web. In *Proceedings of 1st International Workshop on Hypermedia and the Semantic Web* , Nottingham, UK.

[2] IEEE: 1484.12.1 *LOM Draft Standard for Learning Object Metadata.* http://ltsc.ieee.org, 2002.

[3] Engelhardt, M.; Schmidt, T.C. et.al.: *The HyLOs Homepage.* http://HyLOs.fhtw-berlin.de, 2004

[4] Engelhardt, M. and Schmidt, T.C.: Semantic linking – a context-based approach to interactivity in hypermedia. In Tolksdorf, Eckstein: *Berliner XML Tage 2003.* Humboldt Universtität zu Berlin, pp. 55 - 66, Berlin. 2003.

[5] Klyne, G. and Carroll J.J. (Eds): Resource Description Framework(RDF): Concepts and Abstract Syntax. *W3C Recommendation,* http://www.w3.org/TR/rdf-concepts/, 2004.

[6] W3C: XML Pointer, XML Base and XML Linking. http://www.w3.org/XML/Linking.

[7] Grosso P. and Veillard, D, XML fragment interchange. *W3C Candidate Recommendation,* www.w3.org/TR/xml-fragment, 2001.

[8] Miller, L., Seaborne A. and Reggiori A., 2002, Three implementations of SquishQL, a simple RDF query language, in Horrocks , I. and Hendler J.A. (Eds.), The Semantic Web - ISWC 2002, Proceedings. *Lecture Notes in Computer Science 2342* Springer, pp. 423-425.

[9] Kárpáti, A.; Rack, T.; Schmidt, T.C. et. al.: *The MIR Homepage;* http://www.rz.FHTW-Berlin.de/MIR, Berlin 2002.

[10] Feustel, B.; Kárpáti, A.; Rack, T.; Schmidt, T.C.: *An Environment for Processing Compound Media Streams.* Informatica; 25, 2; July 2001; pp. 201 - 209.

[11] Feustel, B.; Schmidt, T.C.: *Media Objects in Time – a Multimedia Streaming System.* Computer Networks 37 (6), December 2001, pp. 729 - 737.