MNECLIB2 – A Classical Music Digital Library

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Abstract—Lately there has been a significant boost of interest in music digital libraries, which constitute an attractive area of research and development due to their inherent interesting issues and challenging technical problems, solutions to which will be highly appreciated by enthusiastic end-users. We present here a DL that we have developed to support users in their quest for classical music pieces within a particular collection of 18,000+ audio recordings. To cope with the early DL model limitations, we have used a refined socio-semantic and contextual model that allows rich bibliographic content description, along with semantic annotations, reviewing, rating, knowledge sharing etc. The multi-layered service model allows incorporation of local and distributed information, construction of rich hypermedia documents, expressing the complex relationships between various objects and multi-dimensional spaces, agents, actors, services, communities, scenarios etc., and facilitates collaborative activities to offer to individual users the needed collections and services.

Keywords—audio recordings, music metadata, music digital library, socio-semantic model

I. INTRODUCTION

WHEN thinking of (digital) libraries, most of us think first at books, journals, magazines, newspapers, photographs etc. Music is not the first thing to come in our minds. However, music captures popular imagination much more than classical library content and, for the most part, it is a language independent cultural expression. Moreover, when considering the artistic endeavors, it is obvious that music has gained the most from the technological progress, and The World Wide Web has provided for easy delivery of music [1]. Consequently, during the last decade, there has been a significant boost of interest in music digital libraries, which constitute an attractive area of research and development due to their inherent interesting issues and challenging technical problems, solutions to which are expected to be highly appreciated by enthusiastic end-users [2]. In this paper we present a digital library - MNECLIB2 - that we have developed to support the user in his or her quest for classical music pieces within a particular collection of more than 18,000 audio recordings (many of them being very rare). The collection has been donated to a private foundation that supports and finances advanced studies in humanities and social sciences, by its owner, a famous literary critic, poet, and radio journalist at an international broadcaster. MNECLIB2

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content includes also textual information on music topics: treatises on music theory, biographies of composers, musicological journals, works on music history etc.During the development of MNECLIB2 we have been subscribing to the Witten and Bainbridge's definition that states that *a digital library is a focused collection of digital objects, along with methods for access and retrieval, for selection and organization, for maintenance of the collection* [3]. This definition accords equal weight to both *user* (for access and retrieval of the content) and *librarian* (for selection, organization and maintenance of the content) and, in our opinion, that poise distinguishes a genuine digital library from other digital collections [3]-[4]. The librarian is frequently overlooked by DL proponents who have an ICT background, and approach this work narrowly paying little attention if any to the perspective of library or information science, which states that selection, organization and maintenance are vital to a library, being it digital or not [3]-[5]-[6]. For instance, the process of selecting the materials to be included in any library is critical, and it has to comply with a particular set of criteria that guarantees that each such material serves the library's purpose, while the services available to the users facilitate the use of the content by the target community. Therefore, *Librarianship* (selection, organization, and maintenance) is essential to a (digital) library, because, in the end, it is *wisdom* librarians put into libraries by deciding what to include, and how to organize and maintain the content [3]-[5]-[6]-[7]. Furthermore, the responsibility of the (digital) librarian is extended to cover the digital services offered by the DL [3]-[7]-[8]-[9].

II. THE SEMANTIC MODEL OF THE MUSIC DL

Music Digital Libraries (MDLs) raise appealing challenges for research, with respect to acquisition, searching and browsing, presentation, and evaluation. First there is the problem of acquiring music content freely available or that complies with the copyright law. Secondly, searching and browsing are to be approached in a coordinated manner that provides for seamless access. Another interesting challenge is concerned with the presentation of the resulted musical information to the user. Finally, the evaluation of MDLs is equally important [1].Of course, MDLs have to be approached in the general perspective of the new digital libraries, which, besides offering classical library services, are much more adaptive, reflecting better their audiences. Moreover, they are expected to provide for collaborative frameworks that allow users to contribute (socially constructed) knowledge to the content of the digital library, both actively by adding semantic

annotations, reviews, ratings, and so on, and passively, by their use patterns. Furthermore, the digital libraries are expected nowadays to be contextual, i.e. to be able to express the web-like interrelationships and layers of knowledge corresponding to the DL's resources, resulting in a vibrant information and knowledge base that benefit dually from professional and collective wisdom [7]. The context of a piece of information is usually quite complex, and it reflects the diversity of the target communities of a particular digital library, which results in different ways of using and processing information and knowledge. Generally, context is multidimensional and it includes a variety of aspects: personal, task, device, social, spatio-temporal, environmental, infrastructure, user interface etc. [10]-[11].

The old model of digital libraries - based on a catalog of metadata records - has failed modeling this wealthy multi-dimensional information space due to its inbuilt shortcomings: first the metadata records were related to individual items, failing this way to capture the complex contextual relationships between the DL resources, to discriminate among the multiple entities involved (resources, actors, ontologies, agents etc.), and to adjust to the changing information needs [7]-[12]. In addition, the metadata's static nature cannot capture the dynamics of the DL resources, which represents changes of preferences, patterns of use etc., and even a cultural shift [7]-[13]. Likewise, that metadata centered model does not provide for a resource centered paradigm that allows management, manipulation, and processing of both content and metadata seamlessly [7]-[14]-[15]. Finally, the early DL model has not been intended to facilitate the development of collaborative and contextual knowledge environments that provide for instruction, education, personal growth, and so on [7]-[16].To cope with the above limitations, we have developed a generic model that is socio-semantic and contextual, and that allows rich bibliographic description of the DL content, along with various activities performed on that content: semantic annotations, reviewing, rating, knowledge sharing etc. This model captures the multi-layered services that work interdependently to offer to individual users the needed collections and services. Furthermore, it allows incorporation of local and distributed information integrated via web services, and construction of rich hypermedia documents. In addition, the model is able to express the complex relationships between various objects (information, content, knowledge, and learning objects) and multi-dimensional spaces, agents, actors, services, communities, scenarios, and meta-information (e. g. ontologies), and thereby represents the information resources in their natural context. Furthermore, it facilitates collaborative activities, closing the loop between users as readers and users as contributors to the content, subscribing this way to the Web 2.0 paradigm [4].For better modeling of our particular music digital library we have refined that generic model, which is shown in Fig. 1, as we will explain in detail in this section. All the *eligible* objects to be added to the DL's content (MP3 digitized audio records,

MIDI files, OMR files, scanned sheet music etc.) are to be found within The Global Information Space. The selection of the objects to be included is directed by a set of guidelines in accordance with the DL's purpose, objectives, and guiding principles. To perform his or her selection duty, the (Digital) Librarian has to use the tools offered by The Collection Management Service.

Once included in the DL content, the digital objects experience, through the Repository and Indexing Services, various manipulations such as storing, organizing, deleting, modifying, indexing, faceting etc., by several people: Digital Librarians, Metadata Agents, ICT Engineers and so on. All this processing is done on the Raw Objects Layer. Facets are an interesting approach and correspond to different semantic points of view of one digital object, and they are tailored by extracting and using the relevant metadata (for instance, meteorologist, volcanologist, agronomist, seismologist etc. "see" several facets of the same satellite images). What is more, the raw digital objects can be reused, or re-purposed for various contexts on the upper layers.

Going up through the model, we find the digital objects semantically enriched by musicology and education experts as information objects, content objects, knowledge objects, or learning objects, laying on two levels: Content Layer and Learning Layer. One or more raw digital objects, not related to any particular objective, create an *information object*. Different delivery systems may use such objects: web pages, knowledge management systems, reference, news, help, E-learning, wizards [17]. A *content object* is constructed on top of an information object, and it is tailored to serve to a particular (instructional) objective, to which is linked to. A *knowledge object is a precise way to describe the subject matter content or knowledge to be taught* [18], and has therefore some achieved instructional value. A *learning object* is obtained by developing further a knowledge object by adding extra-elements such as: task, topic, prerequisites, guidance, sequencing, feedback, assessment, technical requirements etc. It supports specific learning experiences with particular objectives, specific curricular outcomes, and identified target audiences. Learning objects can be identified, tracked, referenced, used and reused for a variety of learning experiences [17].

The User Interface Service allows users and communities to access the digital library's content via typical library services, as searching and browsing, and also to contribute to the content collaboratively by annotating, reviewing, rating etc. the DL resources. Searching is ought to provide for textual searching based on metadata, free full-text search, audio queries, and combined ones. Browsing hinges on the rich bibliographical metadata available. Other helpful services are available as well: musical information presentation, alerting services, high level authoring, visualization tools, analytical services, educational discovery etc. The user may be presented with descriptive metadata, sheet music, audio recordings, lyrics, critical and anecdotic information, musicology works, composer biography and trivia etc.
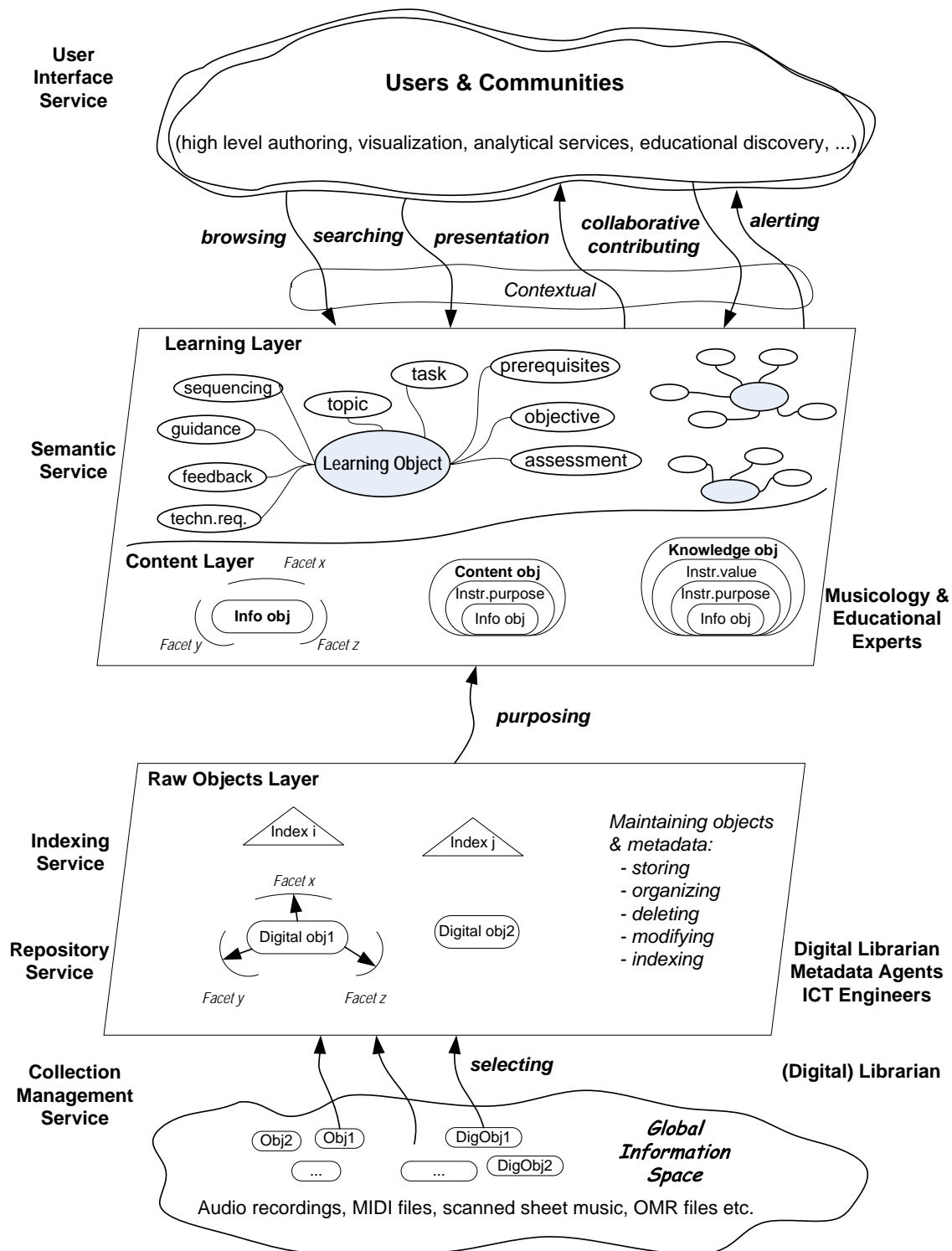
Fig. 1 Semantic Collaborative Model of Music Digital Libraries

Users may benefit from better services, which are more flexible, proactive, and manageable, based on contextual information, which includes the resource provenance, the ways the resource has been used before, the user comments about it etc. In addition, the context may be used to define the (re-)usability of resources in different experiences, and to assess their quality. Hence, contextualization as a means of adding value to the DL's content becomes essential [19].

III. THE LIBRARIAN'S INTERFACE FOR NECLIB2

In this section we are going to present briefly the Librarian interface of MNECLIB2. First, in Fig. 2, we show a screenshot of the form which is used for creating metadata records.

We use a combined technique that incorporates local and distributed information integrated via web services, in a seamless manner. When the Librarian wants to insert a new CD in MNECLIB2, she put the CD in the CD unit and starts a program called Exact Audio Copy (EAC), which is free software that performs audio-grabbing for audio CDs with CDDB support [20]-[21]. Compact Disc Database (CDDB) is a database in which software applications can look up audio CD information over the Internet, based on a nearly unique identifier, which is further used to query the database. The query result includes mainly the artist name, the CD title, and the track list [20]. This identifier is similar to a CD "fingerprint" and it is based on the track duration information that is stored in the CD's table of contents.

In fact, MNECLIB2 uses **freedb** that is similar to CDDB and it was originally based on CDDB (which is now proprietary software) [22]. The content of **freedb** is under the GNU General Public License. **freedb** is used by media players, audio taggers, CD ripper software, cataloguers etc..

After downloading the metadata information that corresponds to a particular CD from freedb that information is parsed and the following features are extracted automatically: the name, author, and genre per album, and the name and the length of each track. For the particular CD used as an example in Fig. 2, the metadata extracted from **freedb** is as follows:

```
# xmcd
#
# Track frame offsets:
#       182
#       70382
#       117332
#       188882
#       216427
#
# Disc length: 3979 seconds
#
# Revision: 33
# Processed by: cddbd v1.5.2PL0 Copyright (c) Steve Scherf et al.
# Submitted via: ExactAudioCopy v1.0b1
#
DISCID=4d0f8905
DTITLE=Herbert von Karajan: Berlin Philharmonic / Beethoven -
Symphony
DTITLE= No. 9
DYEAR=1984
DGENRE=Classical/Symphonic
TTITLE0=Symphony No. 9 in D minor, Op. 125 - I. Allegro ma non
troppo,
TTITLE0= un poco maestoso
TTITLE1=Symphony No. 9 in D minor, Op. 125 - II. Molto vivace
TTITLE2=Symphony No. 9 in D minor, Op. 125 - III. Adagio molto e
canta
TTITLE2=bile
```

```
TTITLE3=Symphony No. 9 in D minor, Op. 125 - IV. Presto
TTITLE4=Symphony No. 9 in D minor, Op. 125 - "O Freunde, nicht diese
T
TTITLE4=öne!"
EXTD=
EXTT0=
EXTT1=
EXTT2=
EXTT3=
EXTT4=
PLAYORDER=
```

As the CDs in a series are often introduced in the freedb by different people one has to deal with the problem of inconsistent spelling and naming conventions across discs. To handle it a musicologist with experience in librarianship validates or corrects the automatically obtained information, and further on, adds more metadata into the form as it can be seen in Fig. 3. The metadata used currently in MNECLIB2 is as follows: album identifier, composer, director, performing artist, album title, sub-title 1, sub-title 2, original title, subjects, English subjects, recorded music company, musical genre, UDC, responsibilities, freedb identifier, freedb genre etc. There is also kept information on the disks that correspond to each album, and on the tracks of each disk. EAC is used also for grabbing the audio tracks of each CD in the FLAK format. The audios may be listened using mp3 with various compression rates. For each album, more than on CD may be inserted.

To build this music digital library we have been using mainly a combination of C, Pearl, PHP, and JavaScript. The current stage of the project: the online catalogue with rich metadata and both relational and free full-text search are fully functional and in use. We are currently in the process of including the digitized recordings in MNECLIB2's content, by using an appropriate storage server.

IV. THE USER'S INTERFACE FOR NECLIB2

In Fig. 4 the results of a combined search both relational and free full-text search are shown. The user has searched for Franz Schubert in the title, and s/he has been presented with four items: (1) a CD album, which contains among other pieces, Symphony No. 5 by Beethoven and Symphony No. 8 (Unfinished) by Schubert; (2) a book, by Emmanuel Buenzod that contains a biography of Schubert; (3) another CD album that includes Schubert's Sonata B-dur D 960, and (4) a CD

Fig. 2 Librarian interface – Metadata extracted from **freedb**

Fig. 4 User interface – a combined search

Fig. 3 Librarian interface – Metadata validated and completed

album with piano concertos by Schuman, Schubert, Grieg and Liszt. For each item subjects, both in our language and English are presented, along with the recorded music company or the publishing house for CDs, respectively books. UDC, call number, reviews, year and place of publishing etc. are available as well.

V. RELATED WORK

Music digital libraries are a topic of interest for several research groups around the world. First, there is the group coordinated by Professor Ian Witten at University of Waikato, New Zealand, which created Greenstone open source digital library software and several Greenstone-based digital libraries [23]. Several of their works on digital libraries address particularly this subject. Their experience and results of building a digital library of popular music is presented in [1]. They have identified the main challenges for research on music digital libraries to fall in four categories: acquisition, searching and browsing, presentation, and evaluation. They also developed a suite of tools for gathering the musical material, for converting between various representations of music, for combined searching based on musical and textual criteria, and for appropriate presentation of searching and browsing. Another of their works explores the role that visual browsing can play within a digital music library by combining techniques from the fields of digital libraries and human computer interaction. Basically, the prototype system combines images located through textual metadata with a visualization technique called *collaging* to provide *a leisurely, undirected interaction with a music collection* [24].

In [25] the authors address the problem of interactive melody retrieval focusing on methods for evaluating different symbolic music matching strategies to produce a hybrid approach. They conclude that effective methods should use both the pitch and the rhythm information of the melodies. Moreover, pitch interval is preferred to absolute pitch, matching only at the start of the pieces reduces time considerably, and approximate matching is necessary.

Another consistent endeavor in DMLs is Variations 2, which provides online access to selected recordings and scores from the Indiana University Cook Music Library [26]-[27]. The team there has been focused on three main areas of research and development: system architecture (content representation and metadata standards included); component-based application architecture; and network services. They have been testing and evaluating commercial technologies for multimedia and storage management, developing custom software solutions for MDLs, integrating commercial technologies with custom ones, and they have properly tested and evaluated the prototype systems for music instruction and library services, locally and at several satellite sites.

In [28] the authors introduce a new form of usability inspection method, namely Ontological Sketch Modeling that may support the design decisions involved in creation of a MDL, by identifying any potential mismatches between designer and user viewpoints. The core concepts of the method are entities, attributes, actions, and relationships. The method has been used to evaluate the New Zealand Digital Library (NZDL) Music Library of the University of Waikato Department of Computer Science [23].

In [29], authors explore the possibility to handle simultaneously two types of digital music documents, scanned sheet music and audio CD recordings, for the same piece of music, aiming to increase the benefits of using such multi-domain information, closing this way the gap between the domains in user applications.

Specific digital libraries are focused on people interested in specific subject as, for example, acquiring knowledge about Brazilian popular music harmony, particularly in Choro [30].

Other authors are concerned with music digital libraries in the broader picture, and approach music as a universal human right, walking the fine line between that and the restrictions of the copyright law [31].

VI. CONCLUSIONS AND FUTURE WORK

Music is idiomatical for all human societies. Different generations identify powerfully with particular musical styles [2]. Moreover, music is intrinsically connected to the quality of life [31]. Albert Einstein put this in words very appropriately: *If I were not a physicist, I would probably be a musician. I often think in music. I live my daydreams in music. I see my life in terms of music.... I get most joy in life out of music* [32].

Digital libraries are expected to promote the digital revolution in music and to develop stylistically broad, comprehensive music collections, supported by popular formats and technologies, so that they are accessible for large communities of users. By not being tied up of the constraints of the classical libraries (physical space, time limitations etc.), (music) digital libraries can be much more adaptive and reflective about their target communities, providing for development of emerging collaborative and contextual knowledge environments.

In this paper we have presented a digital library - MNECLIB2 – that aims to support the users interested in classical music pieces and information. This digital library subscribe to our socio-semantic contextual model for music digital libraries.

Currently, our MDL allows searches based on standard bibliographic metadata or free full-text search. We plan to look into the opportunity of offering melody-based querying as well, and of combining text-based searches with melody matching providing a more comprehensive searching technique for this particular digital library.

Another interesting idea to follow regards the possibility to mine for descriptive, critical, and anecdotal information on particular pieces or persons related to them such as the composer, the performing artist(s), the director and so on, on the Web, which is a wealthy source of opinions, reviews,

catalogs, miscellaneous trivia etc. We also need to investigate further how to include in the future versions of MNECLIB2 all the key elements of the conceptual model and how to extend our model in order to adapt it better to our ever changing world.

REFERENCES

[1] D. Bainbridge, C. G. Nevill-Manning, I. H. Witten, L. A. Smith, and R. J. McNab R.J., "Towards a digital library of popular music", in *Proceedings of 4th ACM/IEEE-CS Joint Conference on Digital Libraries*, Tuscon, AZ, USA, 2004, pp. 161-169, New York: ACM.

[2] D. Bainbridge, M. Dewsnip, and I. H. Witten, "Searching digital music libraries", Information Processing and Management, vol. 41, no. 1, pp. 41-56, January 2005.

[3] I. H. Witten, D. Bainbridge, and D. M. Nichols, *How to Build a Digital Library*, 2nd Edition, Burlington, MA: Morgan Kaufmann Publishers, 2009, pp. 7

[4] M. Vladoiu and Z. Constantinescu, Open Digital Library on Digital Libraries, *Proceedings of 10th IEEE RoEduNet International Conference Networking in Education and Research*, 2011, Iasi, Romania, pp.

[5] M. Lesk, *Understanding Digital Libraries*, San Francisco, CA: Morgan Kaufmann Publishers, 2005

[6] D. Kresh, *The Whole Digital Library Handbook*, American Library Association Editions, 2007

[7] C. Lagoze, D. B. Krafft, S. Payette, S. Jesuroga,"What Is a Digital Library Anymore, Anyway? Beyond Search and Access in the NSDL", *D-Lib Magazine*, Vol. 11, No. 11, November, 2005, available at http://www.dlib.org/dlib/november05/lagoze/11lagoze.html, accessed April 2011

[8] R. A. Eamshaw and J. A. Vince, *Digital Convergence – Libraries of the Future*, Springer, 2010

[9] K. Johnson and E. Magusin, *Exploring the Digital Library: A Guide for Online Teachind and Learning*, San Francisco, CA: Jossey-Bass, 2005.

[10] M. Vladoiu, Z. Constantinescu, "u-Learning within a Context-Aware Multiagent Environment", *International Iournal of Computer Networks & Communications (IJCNC)*, Vol. 3, No. 1, pp. 1-15, January 2011.

[11] M. Vladoiu, Z. Constantinescu, "Learning with a Context-Aware Multiagent System", Proc. 9th IEEE Int. Conference Romanian Educational Network - RoEduNet, Sibiu, Romania, 2010, pp. 368-373

[12] P. Parrish, "The Trouble with Learning Objects," *Educational Technology Research and Development*, Vol. 52, No. 1, pp. 49-67, 2004.

[13] M. Recker, A. Walker, and D. A. Wiley, "Collaboratively filtering learning objects," in *Designing Instruction with Learning Objects*, D. A. Wiley, Ed., 2000.

[14] R. Daniel Jr. and C. Lagoze, "Extending the Warwick Framework: From Metadata Containers to Active Digital Objects," *D-Lib Magazine* November, 1997.

[15] M. Recker, J. Dorward, and L. M. Nelson, "Discovery and Use of Online Learning Resources: Case Study Findings," *Educational Technology and Society*, Vol. 7, No. 2, pp. 93-104, 2004.

[16] D. Greenstein, Lessons in Deep Resource Sharing from the University of California Libraries, Council on Libraries and Information Resources, available at http://www.clir.org/pubs/reports/pub119/greenstein.html, accessed April 2011.

[17] Cognitive Design Solutions - Instructional Design - Learning Objects http://www.cognitivedesignsolutions.com/Instruction/LearningObjects.htm, accessed April 2011.

[18] M. David Merrill, "Knowledge Objects", *CBT Solutions*, pp. 6-11, March/April, 1998.

[19] Lagoze C., Lost Identity: The Assimilation of Digital Libraries into the Web, PhD Thesis, available online at http://www.cs.cornell.edu/lagoze/dissertation/dissertation.html, accessed March 2011

[20] CDDB - Compact Disc Database, available at http://en.wikipedia.org/wiki/CDDB, accessed June 2011

[21] EAC – Exat Audio Copy available at http://www.exactaudiocopy.de/, accessed June 2011

[22] freedb available at http://www.freedb.org/, accessed June 2011

[23] New Zealand Digital Library available at http://www.nzdl.org/cgi-bin/library.cgi, accessed June 2011

[24] D. Bainbridge, S. J. Cunningham, and J. S. Downie, Visual collaging of music in a digital library, in *Proceedings of 5th International Conference on Music Information Retrieval,* ISMIR 2004, 2004, Barcelona, Spain, Universitat Pompeu Fabra, pp. 397-402.

[25] D. Bainbridge, M. Dewsnip, and I. H. Witten, Searching digital music libraries, *Information Processing & Management*, 41(1), pp. 41-56.

[26] Variations - The Indiana University Digital Music Library available at http://www.dml.indiana.edu/, accessed June 2011

[27] M. McRobbie, DLI-2: Creating the Digital Music Library, available at https://scholarworks.iu.edu/dspace/.../Variations2%20Final%20Report.pdf, accessed June 2011

[28] I. Connell, A. Blandford, and T.R.G. Green, Usability of a Music Digital Library: an OSM Case Study, available at http://www.uclic.ucl.ac.uk/annb/docs/ISMIR-OSM.pdf, accessed June 2011

[29] C. Fremerey, D. Damm, M. Muller, F. Kurth, M. Clausen, "Handling scanned sheet music and audio recordings in digital music libraries", in *Proceedings of the 35th International Conference on Acoustics (NAG/DAGA)*, Rotterdam, Netherlands, pp. 350-351, 2009

[30] F. Cruz et al., A Brazilian popular music digital library oriented to musical harmony e-learning, in Proceedings of Int. Conf. on Music Information Retrieval, 5., 2004, Barcelona, Universitat Pompeu Fabra, pp. 429-432.

[31] S. J. Simon, Digital libraries as an access-point to music culture, 3rd International Music Council World Forum on Music (UNESCO IMC), Tunis, Tunisia, available at www.imc-cim.org/programmes/WFM3/papers/session3/Simon.pdf, accessed June 2011

[32] A. Einstein, What Life Means to Einstein: An Interview by George Sylvester Viereck, *The Saturday Evening Post*, October 16, 1929.