1 PUBLISHABLE SUMMARY

Currently, considerable effort is underway, both in terms of human resources and funding supported by the CEU research programs, aimed to develop large digital information infrastructures, including thematic digital libraries, institutional digital repositories and discipline-specific digital data libraries. These digital library infrastructures are optimized for supporting the full life cycle of digital information (i.e., capture, collection, curation, documentation, archiving, and publication). Connecting these infrastructures in order to enable them to exchange data and information and interoperate within a framework of shared policies is an emerging need. Achieving this will contribute to the creation of global information infrastructures supporting multidisciplinary activities.

When data/information/knowledge are moved between disciplines they are taken across at least one, if not more, "knowledge boundaries". These border crossing must be carried out without introducing semantic distortions to the data/information/knowledge. Projects such as Europeana and OpenAIRE are attempting to address these challenges.

DL.org has addressed the complex challenge of making these digital library infrastructures interoperable by adopting a holistic approach. In essence, it has investigated techniques and approaches to create interoperable infrastructures for the conceptual landscape of content, user, functionality, policy, quality, and architecture.

1.1 *Project Objectives*

The DL.org Project objectives were:

- *To create a networked community of theoreticians and practitioners in the field of Digital Libraries in order to discuss the main problems faced when building large scale interoperable distributed heterogeneous digital library infrastructures.*

  DL.org is a Coordination Action, as such its primary objective was to contribute to the creation of an international networked community of theoreticians and practitioners in the field of Digital Libraries. In so doing it has contributed to the development of the future interoperable digital library infrastructures that necessarily require a synergetic action between these two constituencies.

- *To improve and enhance the DELOS Digital Library Reference Model, a conceptual tool enabling the description of the digital library universe.*

  The DELOS Digital Reference Model is the result of an activity carried out under the DELOS Network of Excellence by a small group of researchers. Its purpose was to set the foundations and identify the main concepts of the Digital Library universe. It introduced the relationships among three kinds of relevant "systems" in this area: Digital Library, Digital Library System, and Digital Library Management System. It has presented the main concepts characterising these systems organised around six main domains, i.e., content, user, functionality, quality, policy, and architecture, and it has identified the main professional profiles involved in the design, development, operation, and administration of these systems.

  The objective of DL.org was to produce an enriched and enhanced version of this Reference Model. In addition, the derivation of lightweight versions of the Reference Model for specific categories of stakeholders, in particular for the librarians, was also considered to be an important objective.

The definition of the concepts of the Digital Library universe made feasible the creation of a new artefact, not initially planned, the *Digital Library Reference Model Conformance Checklist* that facilitates the assessment of Digital Libraries for conformance with the Digital Library Reference Model.

- *To define a Conceptual Framework within which to describe the main technical and organizational DL interoperability problems and solutions.*

  Interoperability intended as the ability of two entities to work together very much depends on the working context in which these two entities are embedded. In the context of Digital Libraries, it was decided to consider interoperability from six different perspectives corresponding to the six main concepts of the Digital Library universe (content, user, functionality, quality, policy, and architecture). In order to facilitate the analysis of the DL interoperability challenges and the description of the solutions, an Interoperability Framework has been defined. This Framework also enables assessment of the efficiency and effectiveness of the different approaches to interoperability.

- *To produce best practices, technology patterns, and guidelines in order to guide and assist the developers of interoperable digital library systems.*

  The objective was to translate the interoperability techniques and approaches identified during the state-of-the-art survey into technology patterns, best practices and implementation guidelines enabling the digital library system designers and developers to choose the most appropriate solutions to their interoperability problems when designing their system.

  The identified technology patterns, best practices, and guidelines have been included into the Deliverable “Digital Library Technology and Methodology Cookbook”.

- *To widely disseminate the project findings.*

  Disseminating the Project findings was an important objective of DL.org. In particular, by promoting the DL Reference Model the objective was to contribute to the creation among DL stakeholders a common understanding and language about the DL domain.

  By promoting the Cookbook, the objective was to assist Digital Library system designers and developers in identifying the appropriate interoperability methods for their system.

  By promoting the results of the in-depth survey on interoperability, the objective we aimed to was to raise awareness in the research community of DL interoperability challenges and to stimulate this community to push forward the state-of-the-art in this complex research domain.

- *To contribute to the education in the field of digital libraries.*

  The emergence of Digital Libraries demands new professional profiles. New professional skills must be developed in order to enable the new professionals to interact at different levels and with different tasks with the Digital Library systems. Digital Library curators, librarians, system administrators, system designers, and application developers represent professional classes for which new skills must be defined. There is, therefore, a need for educational material. One important objective of DL.org was the organization of an Autumn School and the production of education material to support professionals in developing new skills for these emerging domains.

1.2 *Work Performed*

To achieve our first objective, the creation and operation of Working and Liaison Groups were instrumental. These groups are composed of external experts. Moreover, the organization of scientific events where members of these constituencies could exchanged ideas and working experiences, and the organization of dissemination events where the Project findings could be presented to the wide international Digital Library community were instrumental also.

In addition, collaborative links with on-going DL projects and relevant DL organizations were established to foster the exchange of experiences and research results.

A critical stage in meeting our second objective was the involvement of the international Digital Library community in an analysis of the different aspects of the Reference Model (RM) and the collection of comments and suggestions produced by the members of this community. Their feedback was carefully analyzed and contributed to our refining the basic concepts of the RM, to our introducing new key concepts, and to our defining more precisely the interrelationships between its basic concepts.

Our survey of the state-of-the-art of research and practice in interoperability in digital libraries was an essential part of our defining the Interoperability Framework [our third objective].

We also used this Framework to analyze the approaches to interoperability adopted by on-going relevant projects.

In order to achieve our forth objective Digital Library interoperability scenarios were identified, analyzed and described in terms of interoperability problems and solutions according to the methodology described in the Interoperability Framework. This activity has enabled us to identify technology patterns, best practices, and guidelines that developers and integrators might follow when implementing interoperable digital library infrastructures.

To achieve the fifth objective we organised scientific events including workshops, special networking sessions, and panels. In addition, the dissemination activity of the Project was supported by the publication of posters, flyers, e-Newsletters, and a dynamic web site.

We produced educational materials in order to achieve the sixth objective. Two Project deliverables the “DL Reference Model” and the “Technology and Methodology Cookbook” were core building blocks in this process. In fact, teaching materials were produced by extracting content from these two deliverables. These materials contributed also to the creation of the Module “Conceptual frameworks, models, theories, definitions” of Wikiversity[2].

Finally, the organization of an Autumn School and a Workshop in cooperation with International Master in Digital Library Learning (DILL - under the European Union’s Erasmus Mundus Program) helped the project partners to acquire a better understanding of the education needs of the digital library community and to customize more appropriately the teaching materials we were developing.

1.3 *Main Results*

- A Networked International Digital Library Community;
- A New Enriched and Enhanced Version of the Digital Library Reference Model;

[2] http://en.wikiversity.org/wiki/Conceptual_frameworks,_models,_theories,_definitions

- A “Digital Library Reference Model Conformance Checklist” to enable assessors to determine whether or not a digital library conformed to the Digital Library Reference Model;
- An Interoperability Framework allowing the analysis and description of interoperability scenarios including problems and solutions;
- A “Digital Library Technology and Methodology Cookbook” describing technology patterns, best practices, and guidelines in order to assist the building of interoperable digital library infrastructures;
- The creation of a module named “Conceptual frameworks, models, theories, definitions” included in the Digital Library Curriculum Project, led by Virginia Tech and University of North Carolina at Chapel Hill, which is part of the Wikiversity initiative;
- The organization of the DL.org Workshop on “Making Digital Libraries Interoperable: Challenges and Approaches” (Glasgow, 9-10 September 2010);
- The organization of the Workshop on “Research and Education in Digital Libraries” (Parma, 9 November 2010);
- The organization of the Workshop on “Theory and Practice in Digital Libraries: A European Approach” (Athens, 13 December 2010);
- The organization of the Workshop on “Digital Libraries and Open Access. Interoperability Strategies” (London, 4 February, 2011);
- Theorganization of the ICT Networking Session on “Global Information Infrastructures for Science & Cultural Heritage: The Interoperability Challenge” (Brussels, 29 September 2010).
- The organization of the DL.org Autumn School on “Digital Libraries & Digital repositories: Interoperability Perspectives” (Athens, 3-8 October 2010).
- The publication of about 20 papers based on the work performed within the DL.org Project.

1.4 *Final Results*

- An Enriched and Enhanced Version of the Digital Library Reference Model.
- A “Digital Library Technology and Methodology Cookbook”, containing best practices and guidelines for assisting people involved in activities of designing, implementing, and operating large scale distributed, heterogeneous, interoperable Digital Library and Repository systems.
- A “Digital Library Reference Model Conformance Checklist” to enable assessors to determine whether or not a digital library conformed to the Digital Library Reference Model.
- Teaching materials addressing the more advanced aspects of Digital Libraries and Digital Library Systems contributing to the DL education.

1.5 *Potential Impact*

The DL.org outputs will have a significant impact on:

- The Digital Library Research community

  The formal definition of the DL Reference Model constitutes for the DL research community a sound basis for conducting research activities in the DL domain. In addition, the study on DL

interoperability is expected to open new research directions which will contribute approaches to address the complex challenges posed by this domain.

- The Digital Library Education Community

  The enhanced and formal definition of the DL Reference Model as well as the rich survey on Interoperability state-of-the-art contribute to improving didactics in the DL domain by providing a framework for the organic/systematic teaching of the different aspects of Digital Libraries.

- The Digital Library Application Communities

  The enhanced *Digital Library Reference Model* and the new Digital Library Checklist contribute to the creation of a common understanding and language for communicating about the DL domain among the DL stakeholders including system designers and researchers.

- The Industrial Communities

  The project outputs (in particular, the DL Cookbook) are expected to help DL system designers and developers to build more efficient interoperable systems by providing them with guidelines, best practices, and patterns which will assist them in identifying the appropriate interoperability schemas.