
# DL.org: Coordination Action on Digital Library Interoperability, Best Practices and Modelling Foundations

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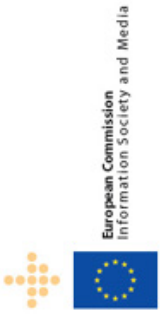


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# Glossary of Terms

| | |
|---|---|
| **DL.org** | Coordination Action on Digital Library Interoperability, Best Practices and Modelling Foundations. |
| **DELOS DL Reference Model** | The DELOS Digital Library Reference Model, copyrighted, which has been developed through the EC project DELOS Network of Excellence. The DELOS Reference Model is the driving principle and conceptual framework behind DL.org, which aims to produce an enhanced and validated version moving beyond the current state of the art. |
| **ECDL** | European Conference on Digital Libraries, annual conferences located in EU cities, proposed as the backdrop for DL.org Workshops. The 1st Workshop is set within ECDL2009, 27 September-2 October, Corfu, Greece. |

# Table of Contents

# Summary

Attended by over 50 participants from the DL community, the 1st DL.org Workshop brought into sharp relief Digital Library (DL) interoperability issues with regard to the six conceptual DL domains captured in the DELOS Digital Library Reference Model, that is, architecture, content, functionality, policy, quality, and user. The Model is providing the framework for deliberations and evaluations led by a large number of experts participating in DL.org's Working Groups and through the support of the Liaison Group and External Advisory Board (EAB).

Stefan Gradmann, a distinguished member of the Digital Library community, delivered a keynote on "Interoperability Challenges in Digital Libraries", with particular reference to Europeana, whose future development depends critically on the effective interoperation of multiple independent pieces. There were eight additional presentations, starting with a brief introduction and outline of the DL.org project and the Reference Model. Six expositions, each related to one of the main DL concepts captured by the Model, focused on the initial outcomes of the collective work of DL.org's Working Groups: content, functionality, user in session one; policy, quality and architecture in session two.

The final part of the Workshop opened the floor to participants offering a springboard for further discussions and exchanges of ideas on effective methods for DL interoperability and best practices. Deliberations revolved around ways in which the Reference Model can be enhanced by identifying commonalities with approaches to challenges in the arena of information systems, as well as pinpointing the specifics that define DL interoperability. Discussion points also focused on addressing mass digitisation in the Reference Model, close collaboration between computer scientists and digital librarians, and fostering forward-thinking approaches in academic courses on information science and library services, such as incorporating current and future versions of the Reference Model, with the aim of enabling the next generation of DL professionals. The Workshop concluded with participants volunteering their own position statements on DL interoperability challenges and DL.org's approach to this highly complex issue.

This Deliverable reports on the focus of the presentations and pursuing discussion points at the 1st DL.org Workshop. Revised versions of the six DL domain-focused presentations based on feedback received will be published by ATLANTIS press in early 2010 in line with the final arrangements made by DL.org and the publishing company.

# 1. Deliverable Outline

The purpose of this Deliverable is to provide a comprehensive report of the 1st DL.org Workshop held on 1st October 2009 in Corfu, Greece within the 13th European Conference on Digital Libraries (ECDL2009). The deliverable opens with the Welcome Message from the Workshop Chairs: Donatella Castelli, CNR-ISTI, Italy, Yannis Ioannidis, University of Athens, Greece, Seamus Ross, University of Toronto, Canada. The Deliverable is then divided into three parts: The Workshop Proceedings, which will be revised based on feedback received by ATLANTIS Press; the main discussion points and finally the Position Statements received from leading figures in the Digital Library (DL) space.
Annex 1 provides the agenda of the workshop. The profiles of the speakers, authors of the 1st DL.org Workshop Booklet and chairs are summarised in Annex 2, while Annex 3 lists the names and affiliations of the workshop participants. Finally, Annex 4 provides a transcription of the two videos made during the Workshop, an interview with Geneva Henry, Rice University and member of the External Advisory Board and Ronald Larsen, University of Pittsburgh and member of the Liaison Group.

# 2. Welcome Message from the Workshop Chairs

The first DL.org Workshop on "Digital Libraries: Interoperability, Best Practices and Modelling Foundations" in Corfu, Greece, on 1 October 2009, in conjunction with the 13th European Conference on Digital Libraries (ECDL).
It is the first workshop organised by the DL.org Coordination Action project, funded by the European Commission under FP7, and comes as a natural continuation of the three "Digital Library Foundations" workshops, held in conjunction with ECDL and Joint Conference on Digital Libraries (JCDL) in 2007 and 2008. Unlike its precursors, however, which addressed any fundamental aspect of Digital Libraries (DLs) from a general perspective, this workshop focuses primarily on DL interoperability. In particular, the workshop presents the initial outcomes of the collective work of a large number of researchers participating in DL.org activities on how DL interoperability can be addressed most effectively.
The DL.org project, which has adopted the DELOS Digital Library Reference Model as the underlying common language for describing DLs, is approaching interoperability in an innovative fashion, by structuring its activities and discussions according to the main conceptual DL components identified in the Reference Model. The workshop uses current DL.org outcomes as a springboard for further deliberations and exchanges of ideas on effective methods for DL interoperability and best practices for other related critical DL issues.
The workshop features presentations from a number of DL experts. Stefan Gradmann, a distinguished member of the Digital Library community, delivers the keynote on "Interoperability Challenges in Digital

Libraries", with particular reference to Europeana, whose future development depends critically on the effective interoperation of multiple independent pieces. The structured part of the workshop programme includes seven additional presentations, starting with a brief introduction and outline of the Reference Model, followed by six expositions of recent research developments and future research challenges in the field, each one related to one of the main Digital Library concepts captured by the Model, i.e. architecture, content, functionality, policy, quality and user. Finally, there is an open discussion session where all workshop participants are invited to brainstorm the future of DLs and the role of interoperability.

First and foremost, we would like to thank all the DL.org external speakers for their willingness to address the workshop audience. We also thank the programme committee members: Marianne Backes, Stephen Griffin, Geneva Henry, and Dagobert Soergel for providing valuable advice and guidance on the programme structure. Special thanks are also due to the ECDL2009 organisers and, in particular, the workshop chairs, Ingeborg Solvberg and Manolis Gergatsoulis, for their trust and assistance in making this workshop a reality. Last but not least, we thank all members of the DL.org Working Groups for the significant amount of time they have taken from their busy schedules to participate in the groups' activities, offering their knowledge and expertise in the ensuing discussions and contributing to the drafting of related documents, all of which form the basis for this workshop's deliberations.

**Donatella Castelli, CNR-ISTI, Italy, Yannis Ioannidis, University of Athens, Greece, Seamus Ross, University of Toronto, Canada**

# PART 1 – WORKSHOP PROCEEDINGS

# 3. Presentations

## 3.1 Welcome Session

### 3.1.1 Keynote by Stefan Gradmann, Humboldt University


Stefan Gradmann's keynote explored interoperability challenges from the perspective of Europeana, a multilingual access point to Europe's cultural heritage, where interoperability plays a fundamental role. The talk evaluated interoperability aspects of selected frameworks for DL modelling, including the DELOS DL Reference Model, as well as abstraction levels, with the aim of pinpointing the conceptual and political complements to the technical approach in DL.org. The talk also illustrated how interoperability challenges in DLs are mostly conceptual with some technical issues and a few political aspects impacting on this core notion. Stefan Gradmann's talk concluded with a reference on an interoperable Europeana. Europeana is not a portal; it provides a portal based on its own API. "*Europeana can be thought of as a network of inter-operating*

*contextualised object surrogates. This network in turn is an integral part of the overall information architecture of the world wide web.*"

**Discussion**

The presentation was followed by a lively discussion, with many participants taking part. The exchange between Donatella Castelli and Stephan Gradmann, opened the floor, addressing the relation between quality, policy and architecture. Though in terms of the interoperability of architecture, there is a reference to quality it does not apply the same to policy. In order to establish the reference to policy it has to involve a specific foundation, that is, accept or not a given institution. Furthermore, it depends on the resources for policy, as it is a delegation model. However, there are no means to establish a centralised policy for quality. Europeana brings together heterogeneous resources (archives, museums etc.) that have very different approaches to policy. Seamus Ross addressed the question if, in terms of defining interoperability, there is one flavour or a multitude of flavours. Stefan Gradmann responded that Europeana is one type of Digital Library but there are other types of DLs. On a technical layer, it is akin to phonetics linguistically speaking. Yannis Ioannidis commented that one of the critical statements on the Reference Model is that it is too computer science oriented. Capturing functionality is absent in traditional libraries. Stefan Gradmann mentioned that in his mind there is the real world in a very broad sense, where there is a difference with regard to cultural institutions in general and eScience, as information objects from abstract sciences is easier to deal with, whereas for cultural institutions it is more contextual. There is a different degree of contextualisation.

### 3.1.2 DL.org – Laying the Foundations of, Donatella Castelli, CNR-ISTI

The Introduction to the 1st DL.org Workshop outlined the project's objectives which include the identification of effective methods for **interoperability** between current and future DL initiatives by adopting a systematic approach and by mobilizing key people and projects. As an ultimate goal, the project will provide the DL community with (a) a DL Technology and Methodology Cookbook, where **best practices** and **successful technological approaches** on key aspects of DL systems will be identified and (b) a consolidated, enhanced and stable version of the **DELOS Digital Library Reference Model**.

**DL.org objectives and focus**

1. Identifying effective methods for **interoperability** among Digital Library Systems. Given the widely distributed nature of future digital libraries, heterogeneity is expected to be the norm. Techniques for interoperability are crucial in reconciling different approaches in such systems. DL.org is undertaking a comprehensive analysis with regard to any of the six domains that characterise DLs by covering a critical review of the current situation and of emerging trends. This evaluation will enable

the identification of techniques, methods and approaches for DL interoperability based on the requirements of existing systems.

2. Pinpointing & promoting best practices and successful technological approaches to key aspects of DL systems. One of the project's key outputs is a **Digital Library Technology & Methodology Cookbook**, containing a portfolio of best practices and outlining patterns and solutions to common issues faced when developing large-scale interoperable DL systems. The Cookbook will also contain guidelines for selecting the appropriate interoperability techniques, standards and approaches when implementing interoperable DL federated systems, or for describing resources which are shareable across systems.
3. Consolidating & enhancing the **DELOS DL Reference Model**. This model, initially conceived within the context of the DELOS Network of Excellence (NoE), lays the foundations of DL systems by capturing their essence. The Reference Model identifies the fundamental entities of discourse within the universe of Digital Libraries (DLs) and organises them around six main domains: **architecture**, **content**, **functionality**, **quality**, **policy**, and **user**. DL.org aims to make a valuable contribution towards a universally accepted Reference Model by validating and refining it through feedback provided by the DL experts working with the project and the wider community.

These objectives are being achieved with the support and active contributions of the international DL research community, specifically through six Thematic Working Groups and a Liaison Group, thus ensuring participation across the board to advance the frontiers of knowledge on DL interoperability. DL.org thus has the ambition to bring to a successful conclusion the long journey undertaken by the DELOS Network of Excellence on Digital Libraries towards filling the gap between current DL practice and the needs of modern information provision.

### DL.org Working Groups

Special emphasis has been placed on important knowledge exchange through the six Thematic Working Groups, one for each of the fundamental DL concepts, aimed at identifying and deliberating the most important interoperability issues for large-scale Digital Libraries, evaluating proposed solutions and contributing to the enhanced version of the DELOS Reference Model. The members include researchers in the DL arena and key representatives from major international DL initiatives and on-going projects who periodically meet together to make progress on the key related outputs. Over the course of the project, the findings of the working groups are offered for broader discussion, consultation and validation to the members of a Liaison Group.

### Liaison Group

The talk highlighted the important contributions of the Liaison Group which is being constituted by stakeholders of DL organizations and coalitions as well as leading experts in the DL field. The Liaison Group serves as a consultation body and as collaboration channel with other projects and initiatives and helps the validation of the outcomes of the Thematic Working Groups.

CERN – European Organisation for Nuclear Research, Switzerland: **Jens Vigen**; Coalition for Networked Information, U.S.: **Joan K. Lippincott & Clifford A. Lynch**; Cornell University, Institute of Informatics Problems, U.S.: **Carl Lagoze;** Cornell University Library, USA: **Dean Krafft;** European Library Users

Advisory Board: **Jela Steinerova**; Indian Statistical Institute: **ARD Prasad**; Internet Archives, U.S.: **Peter Brantley**; King's College London, UK: **Tobias Blanke**; Nanyang Technological University, Singapore: **Schubert Foo**; National Archives of Australia, Australia: **Andrew Wilson**; Open Archive Initiative-Open Reuse & Exchange (OAI-ORE), US: **Herbert Van de Sompel**; Pittsburgh University, U.S.: **Ronald Larsen** Russian Academy of Science, Institute of Informatics Problems, Russia: **Leonid Kalinichencko**; Salzburg Research, Austria: **Andrea Mulrenin**; Tsukuba University, Japan: **Shigeo Sugimoto**; University of Queensland, Australia: **Jane Hunter**; Vienna University, Austria: **Erich Neuhold**

### 3.1.3 DL.org Reference Model, Leonardo Candela, CNR-ISTI

The **DELOS Digital Library Reference Model** stems from an ambitious and challenging initiative spearheaded in 2005 by the DELOS Network of Excellence (NoE) with the aim of providing the DL community with a functional and comprehensive framework that collectively serves the community and captures the intrinsic nature of the diverse entities that constitute the DL universe.

The collective understanding developed by European research groups and through international collaboration within the context of DELOS led to two key outputs: the development of the Reference Model and the **Digital Library Manifesto**. The Manifesto, which is a written statement declaring the intentions, motives, overall plans and views of the initiative, introduces the main notions typical of the DL field as the "systems", the "domains", and the "actors". The Reference Model presents the main concepts, axioms and relationships characterising the domain irrespective of specific standards, technologies or implementations. These foundational artefacts are the starting point for a focused development framework envisioning the definition of other models, such as reference and concrete architectures, leading to the implementation of the aspects captured by the model systematically.

The Reference Model draws clear distinctions between three notions that have often been confused in literature, that is, Digital Library (DL); Digital Library System (DLS) and Digital Library Management System (DLMS). These systems are defined by a set of fundamental concepts belonging to six DL domains, namely **architecture**, **content**, **functionality**, **policy**, **quality** and **user**. These systems support the operations of diverse actors playing four key roles: end-users, DL designers, DL system administrators and DL application developers. The current version of the Reference Model captures and details these aspects through more than 200 concepts and 50 relations that connect them.

The Reference Model thus serves as a lingua franca in the DL domain, encompassing all the activities that require an organised and shared conceptual model, from teaching and research to resource annotation and interoperability. The work undertaken by DL.org since December 2008 is aimed at consolidating and enhancing this Model by harnessing global expertise and providing a forum for knowledge exchange with the broader DL community.

The main open issues of the DELOS Reference Model consist of its complexity and the lack of formal specification as well as the fact that is computer science centric. The talk also made reference to the major releases of the Reference Model planned for late 2009 and September 2010, by amplifying and enhancing the Model through the contributions of DL practitioners and stakeholder participation.

## 3.2 Content, Functionality and User Interoperability

### 3.2.1 Content – Interoperability Approaches, Donatella Castelli, CNR-ISTI

Selecting, digitising, describing, and digitally curating content resources are very time-consuming activities and, often, a primary source of costs for the development of Digital Libraries. Content sharing across DLs is now being promoted as an important strategy to reduce this cost. Also, it is a fundamental approach to foster the greater visibility and use of human knowledge, as well as to generate new knowledge. However, the realisation of a broad and generalised content-sharing is still problematic due to the considerable heterogeneity of models, ontologies and strategies adopted by existing systems and because of the lack of systematic approaches to interoperability.

The talk on content interoperability described the mission and scope of the Content Working Group, placing emphasis on specific interoperability issues in this domain. Content interoperability is a multi-faceted issue arising whenever two entities, usually two software systems, playing the role of provider and consumer are willing to share **information objects** initially owned by the provider only. Facets correspond to different aspects characterising the shared information objects. DL.org's Content working group aims to make progress in terms of identifying appropriate solutions to this type of interoperability. In particular, the group has decided to focus on the subset of information object facets which are the issues being addressed by the Working Group in order to contribute to content sharing by identifying interoperability solutions. Interoperability issues include information object format, attributes, context, provenance, and identifier.

1. **Information Object Format** corresponds to the notion of "data type", that is, capturing the structural properties of the objects. It is a formal and intentional characterisation of all information objects. A consumer can safely and/or efficiently execute operations over an information object based on the structural "assumptions" declared by the associated information object format.
2. **Information Object Attributes** are also known as the metadata that enrich the information object for various management purposes including advanced searches. The granularity of such metadata, as well as their quality, are the defining characteristics of the pool of services that can

be built by exploiting them. The wider the understanding of metadata that the consumer has, the richer the functionality it will be able to realise through its exploitation.

3. **Information Object Context** is a specific kind of metadata devised to characterise the circumstances that form the setting for the information object. This metadata capture the relations with other entities like people, places, moments in time or abstract ideas that complement the object semantics. The relations that link the contextual entities to the objects, in addition to the nature of the contextual entities themselves, are aspects the provider and consumer entities are interested in sharing.
4. **Information Object Provenance** is a specific kind of information object metadata describing the process causing the object to be in its current state. This information is usually context and time -specific, with regard to the aspects captured and their representation, as well as in terms of the objects and processes referred. While standard models for provenance representation are emerging, the heterogeneity of the expected content is a barrier that the provider and consumer have yet to overcome.
5. **Information Object Identifier** is a token bound to the information object that sets it apart from others within a certain scope. By realising interoperability with respect to this aspect provider and consumer become able to refer to the same Information Object univocally.

The talk also explained how the Working Group is developing a comprehensive interoperability framework powerful enough to characterise interoperability problems and solutions in a systematic way as well as evaluating existing approaches and solutions. The Content Interoperability Framework introduces the five axes or facets which are resource feature, abstraction, interaction model/approach, time, and quality. The talk concluded with a reference on the next steps of the Working Group placing emphasis on the definition and stabilisation of the framework, the enrichment of the state-of-the-art survey, the identification of patterns and the enhancement of the Reference Model.

### 3.2.2 Functionality – Towards richer digital library functionality, interoperability and re-use, Dagobert Soergel, University at Buffalo

The Functionality Domain represents the richest and most open-ended dimension of the world of DLs, as it captures all the processing that can occur on resources and activities that can be observed by actors in a DL. Specific interoperability issues that fall within the functionality domain should be primarily related to the traits and properties of the Function concept.

In the DELOS Reference Model, a "function" denotes an action that a DL component or a DL user performs. Thus a "function" is not restricted to mathematical function or to functions in the

programming sense.

This talk presented the main goals and ultimate objectives of DL.org's Functionality Working Group, highlighting interoperability use cases and placing special reference to the Function Interoperability Framework that the Working Group will produce. The goal of the Functionality Working Group is to promote **rich functionality** over a wide range of systems with a consistent interface, promote best practices and innovation, enable finding and reusing software modules that implement desired functionality, as well as enable federated search. These will be accomplished by expanding the Reference Model so that it provides a framework for the **precise description of functions**, and **software modules** implementing these functions for complementary and mutually dependent purposes.
Such purposes encompass educating DL designers, developers, administrators, and users about the rich array of DL functionality, including detailing the description of individual DL functions, thus fostering best practices and innovation. The finding and re-using of software modules that implement the desired functionality is targeted at three groups of people: software developers, DL managers and users. Additionally, the aim is to design and implement **new software modules** that include the desired functionality and that are interoperable with targeted platforms and other modules.
The talk also drew attention to the need to set up an environment in which the DL community can produce a database of function descriptions.The focus of the working group is not on the syntax of a module or service description that is handled by Web standards, but on the **content**. The aim is to provide a very specific vocabulary for the description of a function, such as "browse" to capture sub-functions, characteristics, and interface features so that it is possible to tell from the description whether a given module implementing "browse" meets the requirements at hand.
The group is leading discussions and focusing on explanations of both the different ways in which functions can interoperate and of the "product compatibility" of functions, which, from a user's point of view, equates with similarity in operations as well as look and feel. The exchange of expertise will also enable the development of a template, based on the extended Reference Model, for the creation of a **detailed functionality profile of a DL**, a **DL software system**, or a **DL software module** and the **associated interfaces**. Interoperability issues with regard to function specification include ontologies/taxonomies, function API/interface specification, behaviour description, pre and post conditions specification, specification of composite functions and composition relationships. Interoperability concerns of specific functions and use case include transformation of content from one scheme/form to another, import and export of resource collections, browsing and querying of information, query result ranking, and content annotation use-case.
A number of products are envisioned as outputs from the working group and from subsequent work carried out on the basis of the principles established by its members. One output will be a document describing best practices with regard to functionality coupled with a vision for DL functionality. Work within the group will lead to an improved, more complete and much more detailed functionality section of the Reference Model in terms of both content and presentation, with different modes of presentation for different audiences. The selected functions serve as a starting point to pave the way for the full implementation of this idea, which requires considerable collaborative effort within the

framework established by this working group.
Another key outcome is a pilot in which two large DL systems share information about functions using the tools mentioned above. Related activities comprise teaching modules about DL functionality, forming part of DL.org's training programme with both eCourses and a summer school.
One or more papers produced by individual members of the working group or by the group as a whole will bring into sharp relief key discussion points, conclusions and outputs, with the aim of informing the community at large and enlisting wider collaboration.

**Discussion**

Tiziana Catarci opened the discussion, which revolved around issues such as the generic nature of the functionality framework that can be applied in each software system as well as the proposal of taking into consideration the work in other domains. For example, in service domain issues such as service description and composability have been formally studied. Furthermore, the main goal of the Working Group was reiterated: with respect to the generic nature of the framework a database of function descriptions will include functions specific to the DL domain. Geneva Henry recommended looking at other solutions and efforts such as e-Framework that has produced a lot of work in the area of function specification. She addressed the question what kinds of users the Working Group foresees. Dagobert Soergel responded that the users could be either human or systems/agents.

### 3.2.3 Towards User Interoperability, Yannis Ioannidis, University of Athens

The User Domain is very critical in a Digital Library and represents all the entities that are external to a DL 'system' and interact with it seeking a satisfactory and fruitful experience. As defined in the DELOS Reference Model, the dominant concept of this domain is that of "**Actor**", which could be an **individual person**, a **group of people acting in unison**, or **inanimate entities**, such as software programmes or physical instruments. Digital Libraries connect actors with content and support them in their ability to consume and make creative use of it to generate new content. "**User**" is thus an **umbrella concept** including all notions related to the representation and management of actor entities within a DL. It encompasses such elements as the rights that actors have within the system and the profiles of actors with characteristics that personalise the system's behaviour or represent these actors in collaborations.
The Reference Model, which serves a multi-faceted role within DL.org, facilitates the activity of classifying DL interoperability concerns and provides a framework upon which the focus of the User working group is based.
After several successful discussions, the group has identified **two categories** of **user-level issues** of interoperability of Digital Libraries (DLs) and Digital Library Systems (DLSs): interoperability with respect to what is captured within each DL or DLS about a user as well as interoperability between actors trough

their use of the DL. These two are the focus of the efforts of the Working Group and are briefly analysed below.

**Use-level interoperability** of DLs arises with respect to issues such as user modelling, user profiling, user context, and user management. In principle, two main topics can be distinguished when it comes to interoperability of DLs in respect to the User domain. One is the "object" of interoperation and the other is the "purpose" of interoperation. The "object" is unlimited and can be anything that may be relevant to the user and useful, such as user credentials, user demographics, user access rights, user preferences, user interests, user background, user level of maturity and expertise, etc. The "purpose" could be varied as well: preserving user characteristics across systems (transparent user mobility from one system to the next), mapping user characteristics from one system to the next (non-transparent user mobility), integrating user characteristics maintained about the same user in two different systems, etc. Depending on the "object" and "purpose" of interoperability, there are different use cases that one may imagine. Examples include, consolidating a user's preferences as perceived from his/her presence in multiple systems, retaining the user's access rights as the system transfers him/her to another system, etc.

1. **User modelling** in order to create user profiles that could be shared by different DLs is an important issue for users that work with multiple DLs. The user model captures the kind of information about an individual user that is essential for an adaptive system to behave differently towards diverse users. An instantiation of a user model is a user profile. Up to now, however, there is no generally accepted user model that can be used in every DL application and that can ensure that a profile created within a certain DL may be moved effortlessly to another. Apart from the common user model approach, another one could be to describe and put in place appropriate **mapping mechanisms** within DLs in order to be able to map between different user models.
2. **User profiling** is the process of collecting information about a user in order to generate the user's profile, depending on the current user model. Interoperable DL systems, regarding user profiles, provide users with the ability to have a **personalised DL usage experience**. Having a common model or a way to move a user profile from one DL to another is not enough. On the one hand, there is the issue of **user rights** and how they are propagated from one DL to the other. On the other, there is the issue of **reconciliation** of **different** and, in some instances, even conflicting **preferences** or **user profile characteristics**.
3. **User context** includes issues of how "external" factors affect the user profile and result in differences in user preferences and actions when interacting with a DL. In this sense, user context interoperability may be seen as a generalisation of that of user profiles as the user is one aspect of the context.
4. Interoperability in terms of **user management** refers to the ability of heterogeneous DL systems to work in synergy on issues that are intimately bound up with users' privileges, therefore applying concrete and shared, but transparent to the end-user, authentication and authorisation policies.

I**nteroperability between actors** through their use of the Digital Library is related to **user-to-user interactions** and chiefly includes issues of collaboration and "social" networking in the context of the DLs.

1. **Collaboration.** The basic idea behind collaboration is that users/researchers want to exchange information, ideas and views; a task which has many levels and faces in the context of Digital Libraries. The common thread amongst all of the ideas for collaboration is that the actions of one user can in some way be shared with other users within the system. In the simpler case it involves the act of sharing views or actions on static information provided by the digital library (i.e. on digital objects), while in a more complex situation it introduces tools utilized in the creation and processing of data in a shared context.
2. **Participation.** The participation issue in the context of "user to user interoperability" in a DL goes a step further than supporting collaboration when users work on the same content. The objective is to provide appropriate functionality that will transform the DL to an interactive and attractive experience that will attract the user to utilize the Digital Library in constructive ways for research, entertainment and education. Allowing end users to be content consumers and, in a sense, content providers at the same time is not an easy task and it involves the definition of appropriate policies.
3. **Privacy.** Digital Libraries may have a strong role in supporting the introduction of users to others with similar interests and in fostering the creation of user communities around specific shared topics. Clearly the provision of such functionalities raises an important set of issues relating to privacy and acceptability. It is important that users have a clear means of controlling the degree to which they make information about their interests and information use activities public.

The talk also highlighted the approaches identified to resolve the interoperability issues captured in the state-of-the-art survey. Examples of interoperability approaches are, for the user modelling issue, a General User Model Ontology and a Generic User model Component, and for the privacy issue SemWebDL which is a system addressing several privacy related issues in a multi-library interoperable setting.

Several outcomes are expected to be produced by the working group deliberations and from subsequent work carried out on the basis of the principles established within them. A **state-of-the-art survey** will be produced which will further serve as the groundwork for identifying and evaluating the most appropriate solutions and will lead to the creation of the part of the **Digital Library Technology and Methodology Cookbook** related to the User Domain. Furthermore, the work within the group will lead to an improved, more complete and more detailed "User Section" in the Reference Model. Additional outcomes include contributions to DL.org activities, such as the creation of training material related to user interoperability that will form part of the project's training programme with both eCourses and a Summer School.

**Discussion**

The main issues the discussion addressed focused on the difference between user interoperability and

content interoperability as all end up to the exchange of information objects. The difference is that the types of information objects that are user profiles are related with enough semantics which are very specialized so the exchange of user profiles is not just a content related issue. Exchanging the rules of user profiles is very different from exchanging information objects. Dagobert Soergel recommended language translation as another issue of user interoperability.

## 3.3 Policy, Quality and Architecture Interoperability

### 3.3.1 Policy – Interoperability Approaches, Perla Innocenti, HATII, University of Glasgow and Seamus Ross, University of Toronto

"*There is real potential for this group to provide some useful leadership and guidance.*"
**Steve Knight**, Manager of Digital Strategy Implementation, **National Library of New Zealand**

Underpinning every digital library, there is an organisation governed by an **organisational policy framework**. Digital libraries represent the confluence of vision, mandate and the imagined possibility of content and services constructed around the opportunity of use. It is the policy framework that makes the digital library viable. Without a policy framework a digital library is little more than a container for content - even the mechanisms for structuring the content within a traditional library building as container (e.g. deciding what will be on what shelves where) are based upon policy.

One of the main recommendations that the Policy Working Group addressed to the project partners is to consider the organisational level of digital libraries. Policy governs how a digital library is instantiated and run. The policy domain is therefore a meta-domain which is situated both outside the DL and any technologies used to deliver it and with in the digital library. Policy exists as an intellectual construct that is deployed to frame the construction the digital library and its external relationships and then these and other more operational policies are represented in the functional elements of the digital library. So policy permeates the digital library from conceptualisation through to operation and needs to be so represented in the model at these various levels.

The DL.org Policy Working Group is chartered with investigating and proposing DL interoperability approaches from the perspective of Policy. Taking the DELOS Reference Model as an initial conceptual framework, the working group is investigating policy interoperability approaches and strategies for large scale digital libraries. The Working Group defined policy interoperability for digital libraries as "**business level interoperability**", because, within a policy framework, it is possible to compare and trust values and purposes of each organisation. This type of interoperability does not only concern **peer-to-peer**

**interoperability** but also the **interoperable policies** of third-party service providers, such as data archives and the policy exchanges with cloud providers.

Lack at of policy interoperability at organisational level impacts on machine level, e.g. in terms of lack of DL to DL interoperability, data/document mining mismatch, mismatch of level of staff expertise between diverse DLs. We need policies interoperability at high level and then these needs to be instantiated at process level whether those processes are being handled by human or machine.

The path towards a Policy Interoperability Framework for Digital Libraries presents many challenges. This is a largely uncharted territory - if we look at policy at a organisational rather than only technical level -, modestly investigated in the scientific literature. Another challenge is represented by the fact that very few current DLs have formal policies in place. They do when there are business concerns (e.g. the commercial DLs) and they do for example for access control, but for many types of policies there is very little written down and none of it is machine-readable.

Within the DL.org project time-frame, the Working Group is investigating approaches and strategies related to policy interoperability, and in particular:

- Manual versus automated policies, in particular how to encode those policies for machine discovery, which languages can be used to represent policies, and making them functional, with particular attention to semantic web technologies. The Policy Working Group is further investigating this lack of formalised languages through a survey of relevant international digital libraries. In general, it currently seems too early to expect formally-encoded digital libraries policies in actual digital libraries. There is no standard policy language for the Web as yet and there does not seem to be current digital libraries using any of the identified representation methods, even the ones that interoperate with iRODS.
- Policy management with special emphasis on how policies are appraised and enforced. Here we are looking in particular at the MIT PLEDGE project and the Assessment Framework of the EU-funded SHAMAN project.
- The evolution of policies over time that is how to reconcile policies in a contemporary context and how to handle policy drift.
- The interconnectedness between policy and quality.

The Working Group is also exploring policies outside the traditional DL domain, including the W3C Policy Working Group, policies from the medical domain and the Open Access Initiative. **Descriptive user scenarios** are being produced by the Working Group participants to support the collection and definition of best practices for the use of policies in the DL domain, and as the basis for the example of the new versions of the DELOS Digital Library Reference Model.

The Policy working group collaboratively contributes to DL.org outputs, such as the Interoperability State-of-the-Art Survey and the enhancement of the DELOS Digital Library Reference Model, while working in close synergy with the Quality working group given the close connections between the two concepts and charters.

The Policy Working Group has provided an initial set of recommendations for the enhancement of the policy section within the DELOS Digital Library Reference Model and has completed a preliminary

investigation into existing approaches and best practices with regard to interoperability requirements and policies for digital libraries across multiple domains, scientific literature and pertinent projects.
Future activities of the group will focus on further recommendations for the enhancement of the Policy section within the DELOS Digital Library Reference Model and DL.org's Digital Library Technology & Methodology Cookbook. This activity will be conducted through the collection of accessible DLs policy statements, the survey of operating digital libraries and data centres for verifying the group's findings on policy interoperability, and the further production of user scenarios on Open Access policies, data harmonisation, funding bodies, policy comparability, also from the point of view of the consumer. Upon this work, the Policy Working Group is planning to provide a formal mapping between the PLEDGE policies and the enhanced policy domain in the DELOS Digital Library Reference Model, and to relate to the SHAMAN Assessment Framework.
The group is continuing its investigation into existing approaches and best practices in relation to policy interoperability approaches for digital libraries, is contribute to the DL.org Summer School, and is disseminating its findings through scientific publishing channels.

**Discussion**

The subsequent discussion involved issues such as the non-software engineering approach that is applied by the Policy Working Group, the characterisation of policy as top level issue and the difference of policy from the other concepts of the Reference Model. Stefan Gradmann was pleased to see such domain presented and analysed by a non engineer and suggested to contact the W3C Policy Language Working Group, which has produced many user scenarios and is dealing with Multilanguage issues. Seamus Ross specified in replying to Costantino Thanos that business-level interoperability is operational, a process interoperability, pointing out the difference between policy and content clarifying that content does not instantiate itself in a digital library. Stefan Gradmann commented that policy per se is not the ruling property. Several views can be employed so as to visualise this model but policy is one property that affects all the others. Tiziana Catarci addressed the question if there is a formal language used for expressing typical policy rules. Seamus Ross responded that rules examined by the Working Group are currently being expressed in natural language, but it is being planned to use a structured language.

### 3.3.2 Quality Interoperability, Sarah Higgins, Digital Curation Centre and Giuseppina Vullo, HATII, University of Glasgow

"*In the networked world where people work increasingly on the network, the interoperation between DLs is a network property. Individual libraries may increase interoperability by adherence to standards, but the quality of interoperation with other DLs is as much determined by the quality of the standards. The DL.org Quality Working Group is working enthusiastically to offer a quality framework within the interoperability of DLs networks, fostering knowledge exchange and co-operating with other*

*international initiatives*." **Dirk Roorda**, Infrastructure Coordinator, **DANS**, Royal Netherlands Academy of Arts, a member of the Quality Working Group

Today only a small fraction of all the work on DLs is devoted to quality. The DL.org's Quality working group agrees that a **DL Quality framework** is needed to allow DLs to interoperate and co-operate, exchanging their quality models and data. This investigation takes into account the definitions of quality (what and how to measure), the DL theoretical models and multiple approaches (quality of content, quality of services, quality of policies).

The Quality Working Group is thus chartered with investigating interoperability issues that prevent DLs from working together from the perspective of quality and selects the most pressing issues for further deliberation. The group, which adopts the DELOS Reference Model as its conceptual framework, is working to identify effective and **interoperable quality patterns** and **best practices**.

The aim of the working group is also to promote the exchange of experiences and co-operation between DL initiatives, looking towards the implementation of a common vocabulary in the field and the constitution of a shared framework. The first face-to-face meeting in July 2009 initiated the investigation into existing research and best practices with regard to DL interoperability and quality models. After defining its official charter, which incorporates its mission and scope, the group has agreed on a **quality pattern** serving as a basis for a **core model**, grounded on the **quality concept map** defined in the Reference Model and intended to promote a broadly applicable quality framework to encourage DLs to interoperate.

The Quality Working Group realised that the core business of a digital library is identified as the collection management. To support interoperability a digital library requires an acceptable quality measure and needs to pass a quality threshold. The Quality Working Group identified an **Application Profile** of the DELOS Reference Model Quality Parameter, which is essential to the nature of a digital library and the interoperability across digital libraries. The identified Application Profile has been called **Quality Core Model** and characterises the parameters needed for digital library interoperability quality measure.

The talk also explored the most important parameters for DL interoperability quality measure. These parameters are: the policy parameter, which includes policy consistency and policy precision as sub-parameters and the content parameter with integrity, provenance, and metadata evaluation as sub-parameters.

Considering the organizational level of digital libraries is one of the main recommendations made by the Quality Working Group to project partners. The underlying rationale of this recommendation is that there is an organisation that defines the policy of the overall system in which a digital library is operating. For example, this organisation might be a subject community or a university that does not consider the digital library itself the primary objective of a policy and might not even be termed 'library' at all.

The group is currently focusing on the development of the **Quality Core Model**, with the aim of testing its feasibility and delivering a set of **recommendations**, which will inform both the enhanced Quality Section in the Reference Model and DL.org's **Digital Library Technology and Methodology Cookbook**. In parallel, a selection of case studies will be done: this will allow the Quality working group to analyze some concrete examples of collaborative digital library projects, and to mobilise the professional community, raising the interoperability issue within a broader context.
Additionally, the group will conduct a further investigation into existing approaches and best practices regarding interoperability requirements and quality, produce several user scenarios to develop and bring into sharper relief quality interoperability issues, contribute to the DL.org Summer School in spring 2010, and publish its findings and outcomes.

**Discussion**

The discussion after the presentation of the Quality Working Group was related to issues such as quality measurement and the identification of quality parameters. Sarah Higgins stated that it is important to identify which quality parameters are needed but it is down to the people/DLs to decide the extent to which they can ensure the very best quality. Dagobert Soergel commented that a policy could be constantly applied wrong-headed therefore it does not get the right parameters. A parameter of the collection and of the user is on a different level which is the superficial level. Yannis Ioannidis remarked that monotone dependencies between quality criteria should be identified. Every user is different, so everyone wants different things from the digital library. It should therefore be possible to measure all the different needs. Donatella Castelli pointed out that at the moment the Quality Core Model is more a taxonomy than a model. In order to be a model the quality parameters should be analysed and have specific definitions. Tiziana Catarci mentioned that evaluation of static data quality is relatively easy and should be taken into account by the Quality Working Group. She also pointed out that a quality parameter like the usefulness of a collection for the user is really difficult even to be defined.

### 3.3.3 Architecture Interoperability, Leonardo Candela and Pasquale Pagano, CNR-ISTI

A considerable number of DL software systems have been implemented over the years. These software systems range from Repository Systems, that is, software supporting the development of digital repositories; to DL [Management] Systems of various types, that is, systems offering enhanced services on material aggregated from different data; and systems supporting eResearch, such as, co-operation environments supporting scientists in performing their daily research activities. These systems have been developed independently from each other with very limited effort spent on the design of facilitating technologies that promote the re-use and sharing of assets from other systems. The high costs involved are hampering the wider uptake of innovative DL applications in many domains. The purpose of DL.org's

Architecture working group is to investigate the main barriers preventing different systems from working together from the architectural perspective and to propose approaches and technologies to deal with these issues.

From the Architecture perspective, interoperability concerns software systems of the DL Universe: DL Systems and DL Management Systems. The purpose of interoperability is to enable the use of **architectural components** belonging to one system (the provider) from another system (the consumer). These can be **software components**, that is, artefacts implementing a set of functions, or **system components**, such as running elements contributing to the operation of the overall system like hosting nodes and running web services.

The Architecture working group has identified two main, related aspects concerning architectural components that are particularly critical when addressing interoperability: **component profile** and **application framework**.

1. **Component Profile**. Each architectural component is associated with a profile that describes its characteristics. The richer the profile, the higher the possibility of re-using the component in a context different from the context it has been developed for. For example, a profile clearly and systematically characterising the functionality implemented by a software component can enable the service of another system to dynamically select the component and aggregate it in a workflow implementing a desired functionality. Similarly, the availability of a rich system component profile can support the development of a system that automatically selects, through a match-making process, the most appropriate server from those available to host a certain software component.
2. The **application framework** characterises both the software architectures and the system architecture which the component has been conceived to work with. The framework captures component roles, component-to-component interaction patterns, and prescribes interfaces and protocols to which components should conform in order to interact, that is, exchange information. For example, the systems component conceived to operate with the support of a Registry can be successfully re-used, is a scenario that provides them with the same support. An understanding of the framework the component has been designed for is a necessary prerequisite for interoperability.

The above aspects are only very marginally addressed in current DL architectures since distribution and re-use have emerged only recently as important factors for increasing the sustainability of DL applications. Given the novelty of the topic and the complexity of the Architecture context, the Architecture Working Group has decided to initiate its activities by focusing on the analysis of the interoperability issues outlined above, within the context of two specific classes of **architecture components**: **content storage** components, dealing with the storage of information objects; and content **access components**, in charge of offering the necessary functionality to access information objects in all their parts and relations.

In order to pinpoint proposed solutions, the working group is also performing a survey on the approaches to interoperability with regard to the identified aspects implemented by well-known DL Systems offering content storage and access facilities.

The Architecture Working Group is focusing on the design and testing of interoperability approaches in concrete scenarios, particularly **D4Science** and **DRIVER** projects, as well as reference architecture for interoperability-oriented application framework.

**Discussion**

After the last presentation the considerable overlap between the Functionality Working Group and the Architecture Working Group was highlighted. Finally, Donatella Castelli commented that at the first Reference Model Workshop, in Frascati, Italy, on 1-2 June 2006, there was a consensus that architecture should be part of the Reference Model. One of the most important aspects that was lacking was reference architecture.

# PART 2 – INTERACTIVE DISCUSSION

"*The work on DL interoperability, best practices and modelling foundations will not stop at the end of the project. While DL.org has not yet drawn any conclusions, the project has started to explore many aspects with regard to DL interoperability, across the six domains identified in the DELOS Reference Model*." **Yannis Ioannidis, University of Athens**

The Interactive Discussion offered a springboard for further discussions and exchanges of ideas on effective methods for DL interoperability and best practices. The discussion revolved around issues such as how the Reference Model can be enhanced, addressing mass digitisation in the Reference Model, close collaboration between computer scientists and digital librarians, and the incorporation of current and future versions of the Reference Model in academic courses, with the aim of enabling the next generation of DL professionals.

## 4.1 DELOS Reference Model, the Cookbook and Interoperability Issues

**Views expressed on generic versus specific approaches**

In many cases interoperability has to be approached from a very generic perspective which at some point has nothing to do with the digital library. For example, in the content domain, first should be considered what being interoperable with respect to content means and then focus on the different kinds of content that exist in the digital library world. First, the creation of a generic model is important and then a particular instantiation of it can be created. **Paolo Manghi**

The outcomes of the working groups should express an instantiation of the modelling approach. Interoperability is a very wide area and recommendations or frameworks from the different working groups will really help. A result of this project is expected to be a Cookbook which will describe in a general way, with the right level of abstraction, the different approaches. The users of the Cookbook will make the analogy between the requirements of their Digital Library and the concepts described in this document. It will not be difficult to make this analogy if

the Cookbook includes abstract descriptions along with use cases, or scenarios. **Julie Verleyen**

Coming from a background of architecture modelling where two other layers are on top of architecture layer, the information domain and the business domain. Adding these two layers to the architecture domain of the Reference Model explicit modelling languages can be adopted to model these concepts which will be really helpful for the Quality and Policy groups. **Maarten Steenhuis**

Digital libraries are information systems, so when someone talks about problems related to interoperability within digital libraries it is not surprising that many of the concepts that come up with apply more broadly in any kind of information system. Specialisation comes only when someone applies certain principles to a specific function, or a specific type of function. **Dagobert Soergel**

I am very pleased that everything has been done so far is generic and can be applied to any kind of information environment. If we want to be more precise we have to agree on what a digital library is. Europeana is not called a Digital Library for a number of reasons. The term Digital Library would create lots of confusion rather than help. **Stefan Gradmann**

The idea of the Cookbook is to produce a document where for each specific scenario will suggest some solutions and for each solution will give some quality parameters, like any book in software application. The Cookbook is not a thing that describes what a digital library is, is just collection of pre-cooked solutions. **Leonardo Candela**

DL.org is trying to provide a framework, a model of what interoperability between systems is from different perspectives. Once there is a generic enough framework, the mapping to existing solutions can be done. Nobody has ever done this before in academia; people have provided solutions but not generic models that applied everywhere. **Paolo Manghi**

What characterises a digital library with respect to any information system is more at a concrete level, not at conceptual level. When someone starts materializing the functions, the functionalities and the roles then it becomes different. One example of this is the function “indexing”. Is it the same “indexing” that exist in other information systems? Is it performed by the same kind of users? The Cookbook should be structured in such way in order to get from other proposals without reinventing the wheel, and identify what it is really peculiar, without being too abstract or too practical. The creation of a comparison dictionary could be very interesting. **Tiziana Catarci**

Creating a comparison dictionary could be useful but on the other hand is extremely time-consuming. The State-of-the-Art survey is trying to do this in an ad hoc way. The DELOS Reference Model does not need to be over-specified. This is a framework and someone can look at it and customise it to any particular case. **Yannis Ioannidis**

Web Science is an initiative aimed at understanding and engineering the Web. There are several similarities in the approach. The Web cannot be controlled because the Web is self-constructed. Maybe DL is also self-constructed. Maybe it is acceptable to lose a little control in the digital library and in a way let it evolve but try to influence and then measure the impact. **Ghislain Sillaume**

Digital libraries’ specific issues will only appear at a lower abstraction level, not at the level of the Reference Model. These issues belong in the Reference Architecture and should be discussed in this context rather than blend several levels of abstractions in the Reference Model. The Reference Model should remain generic. **Stefan Gradmann**

It would be really useful to have a toolkit that will help people to assess the quality of digital libraries, including interoperability, just like DRAMBORA does for preservation. **Dagobert Soergel**

If the community feels that is very important and based on volunteer moves in this direction, this can be developed in a couple of years or as part of another project. **Yannis Ioannidis**

### Additional points: Mass Digitisation

*"The Reference Model should not only take into consideration technical work in other fields, where similar issues are being addressed, but should also encompass mass digitisation, as it could lower the value-add of the document. DL.org should therefore carefully consider the full implications of addressing or not addressing mass digitisation",* **Geneva Henry**

The recommendation that mass digitisation be addressed in the Reference Model because it is a fundamental issue met with wide consensus, with Sarah Higgins stating that the mass digitisation in the current Reference Model needs to be drawn out and expanded upon. Perla Innocenti remarked that mass digitisation is definitely considered in the Policy Domain.

### Additional points: possible case study

Next February (2010) the Faculty of Informatics at Masaryk University, which is conducting an investigation into interoperability in the field of mathematics, will be starting the European Digital Mathematical Libraries. The Faculty will need to know how to join other DL mathematics libraries. The Faculty could instantiate DL.org's theory, thus forming the basis of a case study for DL.org.

## 4.2 Closer collaboration between computer scientists and digital librarians

There was a general consensus that innovative approaches in academic settings and closer collaboration with the Library community opens up an important window of opportunity. However, some participants with a more technical background expressed reservations. In several respects, this point remains an open question.

| Views expressed on cooperation between computer scientists and digital librarians |
|---|
| The project needs to make an effort to bring into play librarians as soon as possible as this would help avoid the discourse being computer science dominant. At least one level of the Reference Model should be made accessible to the community. It is important to make the efforts within DL.org accessible to librarians. **Stefan Gradmann** |
| We need to educate people from libraries so they can see the advantages of all the possibilities. **Dagobert Soergel** |
| Digital libraries carry an important baggage of skills and knowledge, as they need to understand what they are trying to deliver to their community of users in terms of architecture and software. While they do not know the deeper complexities that computer scientists deal with, their experiences and knowledge bring value-add to the technical work within DL.org and beyond. **Sarah Higgins** |
| The integration between engineering/computer science and the library domain is already starting to happen. I used the DELOS Reference Model in my library science course at university. **Giuseppina Vullo** |
| There will always be a gap between the two groups. What's the right level of interaction? I am sceptical about this gap. The boundaries are blurred with the risk of being stuck in-between. Librarians can understand a few concepts, but they cannot learn so much and it should not be their duty to do so. **Paolo Manghi** |
| You need to know that the concept of librarian with regard to DLs is completely different from ours. They are very much into emulator thinking. We need to make them understand what we are talking about. **Stefan Gradmann** |
| It is important to exchange knowledge across a broader spectrum; members of both the Policy and Quality Working Groups are good examples of bringing together experts from engineering and the library domain, working together fruitfully. **Giuseppina Vullo** |
| Focusing on such a dichotomy is the wrong perspective as the aim is not to teach them computer science. The |

issue is not about computer science teaching. I think here we should not simply leave the RM as an engineering model because we are cutting out lots of other communities. **Stefan Gradmann**
Several issues, from understanding and choosing the right software to dealing with metadata, are knowledge possessed also by digital librarians and not problems circumscribed to computer science. **Sarah Higgins**
Librarians are also digital library managers and can advocate digital libraries and ask for funding. **Perla Innocenti**
Academic libraries are more advanced/evolved but it will not happen unless we educate the librarians. **Dagobert Soergel**
Are we mature enough in our understanding to educate them? **Yannis Ioannidis**

# PART 3 – POSITION STATEMENTS

Several key experts attending the workshop provided their position statements on the current landscape of digital libraries, feedback on the workshop and key points to be addressed for DL.org.

### Rike Brecht - Ilmenau University of Technology, Germany

One of the results of the project is a DL Technology and Methodology Cookbook. The consortium should have in mind two things:

1. Who is the Cookbook targeting? What kind of requirements do they have? (*Users* of the Cookbook)
2. Discussing about patterns and scenarios consortium should try to find out what are the common, recurring issues faced when developing DLs? (*Content* of Cookbook)

### Schubert Foo – Nanyang Technological University, Singapore

Good work from all working groups! Congratulations!

1. Due to the autonomous nature of each group, there is a need for communication to arrive at a "final" level of abstraction and interoperability guidelines formulation.
2. Some form of formal description of DL is useful as part of the outcome as DLs are conceived differently. The formal description will help identify areas of interoperability in between DLs.
3. The interoperability definition appears to be different among groups which makes item 1 more difficult to achieve. The Quality WG seams to have the highest challenge to define their boundaries/parameters/criteria for defining their guidelines.
4. Useful to include Librarians but they might not be involved with all the areas. Some librarians (more specifically trained/inspired) can handle the whole Reference Model. I would expect the newer generation of librarians be equipped with digital librarians' skills/knowledge.
5. I will give more feedback when I have the time to review the WGs' documents.

### Stefan Gradmann – Humbolt University, Germany

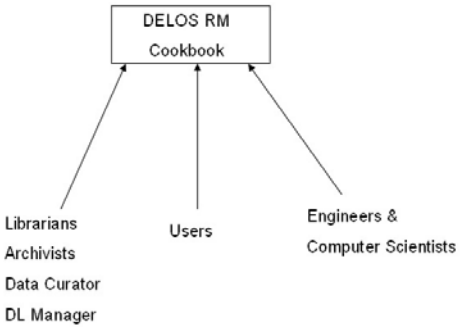
Suggestions:

- Produce a DL.org primer document for the non-initiated (e.g. librarians).
- Develop on DL-specific issues a new version of the Reference Architecture document.

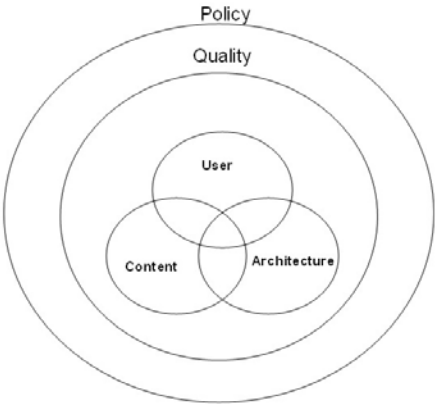
### Geneva Henry – Rice University, Houston, Texas, U.S.

- The 6 domains need to define their interdependencies and impacts to the other domains. They cannot be researched and developed as silos in the framework.
- Need to meet with groups who have already done significant work on information systems frameworks. The e-framework has invested significant resources in this. DL.org can both borrow from this work and contribute to it to develop a rich interoperable framework that will support interoperability with more than just digital libraries.
- What about mass digitization? Is that effort being considered in the DL.org activities?
- Preservation and sustainability are other factors that are critical. Where do these fit in the proposed framework?
- User interoperability is really a need to define user/use case scenarios that feed into functional interoperability.

### Perla Innocenti – University of Glasgow, UK




### Sarantos Kapidakis – Ionian University, Greece



Functionality is the result of the combination of the other 5 issues, the one that we are mostly interested in achieving.
A different subject:
Possible roles for Librarians on the Reference Model:
Collection development (acquisitions)
Cataloguing Librarian
Classification Librarian
Reference Librarian
Reporting (statistics) Librarian
etc.

### Ronald Larsen – University of Pittsburgh, School of Information Sciences (U.S.)

Good Workshop! Well done!

1. Consider whether Leigh Star's concept of "boundary object" may have a role in understanding issues of interoperability.
2. Peter Brusilovsky's work on adaptive user modeLling may also inform the development of the user modeling component.
3. A challenge-based framework along the lines of TREC may draw in other participants as well as communicate what we are trying to accomplish to a broader community.
4. The CFP is out for the 2010 iConference at UIUC. It would be good to engage the iSchools in the DL.org discussion, and the iConference provides a near term opportunity to do so.

### Paolo Manghi – CNR-ISTI, Italy

Separation between "generic framework" (any IS) and specific instantiations in the DL world for that frameworks.

### Oddrun Pauline Ohren – Norwegian Archive, Library and Museum Authority, Norway

First I think the DL Reference Model is a great initiative and has come a long way to create a conceptualisation for the DL domain. However, it is not perfect and is also "uneven" in the sense that the detailing and decomposition in the various domains are done very differently. QP WG has pointed out some important QP but has not really said much about the QP model itself. E.g. QP may be assigned to any object on any level of a DL. How should they be aggregated e.g. how will a QP value of a single object influence a QP value of the collection of which it is a part and the whole DL? At which component level should QP be assigned?
Policies might be expressed with *rules/constraints* or *goals*, for which formal and/or modelling languages do exist.
QP WG suggested including the organisational context in the model. Is it also sensible to include environment as a general concept, modelling the society with its authorities. The rules and regulations will greatly influence the policies of the DL.

### Radoslav Pavlov (representative – Desislava Paneva-Marinova) – Institute of Mathematics and Informatics at Bas, Bulgaria

Very interesting and useful session!

Suggestion: To be organized training session/tutorial or online e-learning/training on DL interoperability, Best Practices and DL Foundations in front of DL developers, DL end-users, administrators or other actors in order to be appreciated the project's approach or to be promoted. We are interested of a participation in such forum.

### Ghislain Sillaume – CVCE, Luxembourg

1. Seems to be similarities between the work being conducted here and the objectives of Web Science initiative (but applied to DL rather the Web):
    a. Need to cooperate with other disciplines.
    b. Need to deal with a very complex and evolving information system.
    c. Need to engineer things and evaluating impact.
    d. Commons interests like identity, trustability, privacy.
2. May be useful to involve User Experience Specialist (mean psychologists). There are already publications from their side that exist about DL.

### Dagobert Soergel – University of Bufalo, U.S.

Determine overlap between WGs:

- Functionality with Content: interoperability of functions with data, interoperability of functions based on data, detailed descriptions of functions that deal specifically with digital objects: ingest, format conversion, display of complex objects, annotation
- Functionality with Architecture: Software Component, component profile. Function and software component description has two parts: (1) Description of what the function does for whom as related to DL services and behind-the-scenes operation (Functionality WG) (2) API, how software modules work together, composition, syntax of such descriptions etc., Web services specification (Architecture WG). (1) and (2) together make a complete description/specification/profile.
- Functionality with User: (1) User requirements as related to function description (2) Detailed description of functions relating to users, such as authentication and user profile creation.
- We may want to encourage all working groups to keep a log of quality parameters and policy problems as they encounter them.

The Quality WG needs to cover quality at a higher level as it relates to services to users.

The Cookbook should have a section for assessing the quality of a DL. In the future it would be useful to have toolkit for assessing DL quality (an expansion, in a way, of the DRAMBORA toolkit for assessing the preservation function) perhaps a follow-on project.

At least one person mentioned to me that a database of detailed function descriptions would be incredibly useful to designers, especially if it includes design patterns (user interface oriented) and software components (implementation oriented). There are many places where content for such a database is already available, it is a matter of making all of this available in on place.
Geneva Henry mentioned that we should look at the JISC eFramework and build on what they have done.

### Petr Sojka – Masaryk University, Faculty if Informatics, Czech Republic

We will soon need "instantiation" of DL Reference Model in the EUDML- European Digital Mathematical Library (EU Project) starting in 2/2010. It should serve as "pilot B" project to make existing DML's interoperable (http://dml.cz/, http://www.numdam.org/). In other words, I offer EUDML being an instantiation of DELOS.

### Maarten Steenhuis – Leiden University Libraries, Netherlands

- Extend Reference Model Architecture with explicit layers that permit Content Modeling, Quality Modeling, and Policy Modeling.
- Build dynamics (creation, scenarios) into the Reference Model.
- Focus on relevance for interoperability.

### Julie Verleyen – Europeana, Netherlands

Keep going and especially in the following direction: develop guidelines, "cookbook" (you name it) that would support someone asking himself/herself the relevant questions on how to develop/maintain solutions meeting certain interoperability requirements. The WGs' documents would combine the right level of abstraction and use (uses, examples etc.) that would allow that someone to easily make analogies with his/her needs and that would avoid him/her not to miss anything important to reach interoperability.
One remark: interoperability regarding policies seemed the less easy to grasp.

### Giuseppina Vullo – University of Glasgow, UK

Freedom of information
Integration of competences
Open Information spaces
Equality
Participation
Exchange
I think these ethic values are behind the focus of the success of the charm of interoperability and the success of this workshop.

# 5. References

Candela, L.; Castelli, D.; Ioannidis, Y.; Koutrika, Y.; Meghini, C.; Pagano, P.; Ross, S.; Schek, H. and Schuldt, H. (2006). *The Digital Library Manifesto*. DELOS: a Network of Excellence on Digital Libraries

Candela, L.; Castelli, D.; Ferro, N.; Ioannidis, Y.; Koutrika, G.; Meghini, C.; Pagano, P.; Ross, S.; Soergel, D.; Agosti, M.; Dobreva, M.; Katifori, V. & Schuldt, H. (2008). *The DELOS Digital Library Reference Model* - Foundations for Digital Libraries. DELOS: a Network of Excellence on Digital Libraries

1st DL.org Workshop Booklet on Interoperability, Best Practices and Modelling Foundations, http://www.dlorg.eu/uploads/DL%20Interoperability/Booklet_web.pdf

# 6. Annexes

## 6.1 Workshop Agenda

**Date:** Thursday, 1 October 2009, **Venue:** Corfu Holiday Palace Hotel, Kanoni, 4 Km from Corfu Town, Corfu, **Host Event:** ECDL '09 - The European Conference on Digital Libraries

| | |
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| **9:00-10:30** | **Welcome Session**<br>**Chair:** Costantino Thanos, CNR-ISTI |
| | **Welcome & Introduction**<br>*Donatella Castelli, CNR-ISTI, Yannis Ioannidis, University of Athens, Seamus Ross, University of Toronto*<br>**Talk: DL.org Reference Model**<br>*Leonardo Candela, CNR-ISTI*<br>**Keynote Talk: Interoperability Challenges in Digital Libraries**<br>*Stefan Gradmann, Humboldt University* |
| **10:30-11:00** | **Coffee break** |
| **11:00-13:00** | **Session 1** – Reports & Visions from Content, Functionality, and User Working Groups<br>**Chair:** *Geneva Henri, Rice University* |
| | **Content Interoperability**<br>*Donatella Castelli, CNR-ISTI*<br>**Functionality Interoperability**<br>*Dagobert Soergel, University at Buffalo*<br>**User Interoperability**<br>*Yannis Ioannidis, University of Athens* |
| **13:00-14:30** | **Lunch** |
| **14:30-16:30** | **Session 2** – Reports & Visions from Policy, Quality, and Architecture Working Groups<br>**Chair:** *Seamus Ross, University of Toronto* |

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|---|---|
| | **Policy Interoperability**<br>*Perla Innocenti, University of Glasgow*<br>**Quality Interoperability**<br>*Sarah Higgins, Digital Curation Center (UK) & Guiseppina Vullo, University of Glasgow*<br>**Architecture Interoperability**<br>*Pasquale Pagano, CNR-ISTI* |
| **16:30-17:00** | **Coffee Break** |
| **17:00-18:00** | **Interactive Discussion** - **Chair:** Yannis Ioannidis, University of Athens |
| *Opening the floor to participants to exchange experiences on interoperability issue, offering feedback on the DELOS Reference Model and the DL.org approach to interoperability challenges. Specific questions and challenges can be posted in the suggestion box at the start of the Workshop and during breaks.* | |

## 6.2 Speaker & Chair Profiles

The section below provides the profiles of the speakers and authors of the 1st DL.org Workshop Booklet.

### *Keynote Speaker Profile*

**STEFAN GRADMANN, HUMBOLDT UNIVERSITY**

Stefan Gradmann is Professor for Library and Information Science at Humboldt University in Berlin where his focus is on knowledge management and semantic technology. He has good knowledge and experience in digital libraries, library automation and information technologies, with a special emphasis on the digital humanities. His second area of expertise is digital identity management as well as authentication and authorisation technologies. His third area of interest is document management and document life-cycle management. He has directed major shared cataloguing networks, working for OCLC/Pica as a product manager and on open access publication models, serving also as deputy director of Hamburg University's computing centre (RRZ), before taking over his new position in Berlin. In parallel, he is currently heavily involved in the building of Europeana, the Europe's multilingual Digital Library.

### *Speaker profiles in order of presentations*

**LEONARDO CANDELA, CNR-ISTI**

Leonardo Candela is a researcher at the Networked Multimedia Information Systems (NMIS) Laboratory of the Institute of Information Science and Technologies, National Research Council, Italy (CNR-ISTI). Leonardo graduated in Computer Science in 2001 at the University of Pisa and completed a PhD in Information Engineering in 2006 at the same institution. In 2001 he joined the NMIS Laboratory and since then has been involved in CYCLADES, Open Archives Forum, DELOS,

DILIGENT, DRIVER and D4Science projects. He was an active member of the DELOS working group on the Digital Library Reference Model. He is member of the OAI-ORE Liaison Group. His research interests include Digital Library Management Systems and Architectures, DL Models, Distributed Information Retrieval, and Grid Computing.

## DONATELLA CASTELLI, CNR-ISTI

Donatella Castelli is a senior researcher at CNR-ISTI. She graduated in Computer Science at the University of Pisa and since 1987 has worked at CNR-ISTI. Donatella has actively taken part in several EU and nationally funded projects on Digital Libraries and Research Infrastructures. In the framework of the DELOS FP6 Network of Excellence, she led the activity dedicated to the production of the DELOS Reference Model for Digital Libraries. She is currently the scientific coordinator of the D4Science and DL.org projects. She is also involved in the technological design of the DRIVER-II and EFG infrastructures. Her research interests include digital libraries content and architecture modelling and interoperability.

## DAGOBERT SOERGEL, UNIVERSITY AT BUFFALO

Dagobert Soergel is Chair of the Department of Library and Information Studies, Graduate School of Education, University at Buffalo and since 2007 has also served as *Professore Onorario*, at the Engineering Department, University of Trento. He has been working in the area of classification (taxonomy, ontologies) and thesauri both practically and theoretically for over 40 years. He is the author of the still-standard text- and handbook *Indexing Languages and Thesauri. Construction and Maintenance* (Wiley 1974) and of *Organizing Information* (Academic Press 1985), which received the American Society of Information Science Best Book Award, as well as numerous papers and presentations in the area of classification/ontologies and more broadly in information science. He has taught courses at several universities in the US and Germany, and is providing a long-running tutorial on Knowledge Organization Systems (KOS) in Digital Libraries at the European Conference on Digital Libraries (ECDL) and at the Joint Conference on Digital Libraries (JCDL) in the US. He has written about the future of digital libraries and led the editing team for the DELOS Network of Excellence (NoE) in Digital Libraries, in response to the EU's call for online consultation, serving also as a member of the DELOS Working Group on the DELOS Digital Library Reference Model. In 1997 Dr. Soergel received the highest award of the American Society for Information Science, the Award of Merit and in 2009 the Contributions to Information Science (CISTA) Award of the Los Angeles Chapter of ASIST.

## YANNIS IOANNIDIS, UNIVERSITY OF ATHENS

Yannis Ioannidis is currently Professor at the Department of Informatics and Telecommunications of the University of Athens. He received his Diploma in Electrical Engineering from the National Technical University of Athens in 1982, his

MSc in Applied Mathematics from Harvard University, and his PhD degree in Computer Science from the University of California at Berkeley in 1986. His research interests include database and information systems, digital libraries, personalisation and social networks, scientific systems and workflows, eHealth systems, and human-computer interaction, topics on which he has published over a hundred articles in leading journals and conferences. His research has been funded by various government agencies (USA, Europe, Greece) or private industry in the context of over thirty research projects, including DELOS, BRICKS, DILIGENT, TELplus, PAPYRUS, and DL.org, which have a Digital Libraries focus. Dr. Ioannidis is a "Fellow" of the ACM (Association for Computing Machinery) and the recipient of the "Presidential Young Investigator" (PYI) award, of the VLDB "10-Year Best Paper Award", and of several awards for teaching excellence. He currently serves a 4-year term as the ACM SIGMOD Chair and is a member of several scientific advisory boards, including the Max Planck Institute for Informatics and the National Council for Research and Technology of Greece.

## PERLA INNOCENTI, UNIVERSITY OF GLASGOW

Perla Innocenti is Co-Principal Investigator in the EU-funded projects Sustaining Heritage Access through Multivalent ArchiviNg (SHAMAN) and Digital Library Interoperability, Best Practices and Modelling Foundations (DL.org). Perla has been involved in repository design and audit research as part of DigitalPreservationEurope (DPE) and Digital Curation Center (DCC), co-ordinating activities and development for the Digital Repository Audit Method Base on Risk Assessment (DRAMBORA) Toolkit. Perla has also contributed to usage models research within the EU-funded project Preservation and Long-term Access through NETworked Services (Planets), as well as to the investigation of the potential application of the DRAMBORA toolkit in the context of digital libraries within the DELOS project and to the refinement of the DELOS Reference Model in relation to digital preservation. Her research interests include digital preservation methodologies and technologies, audit and risk assessment for digital repositories, digital library design and usage models and digitisation methodologies.

## SEAMUS ROSS, UNIVERSITY OF TORONTO

Seamus Ross is the founding Director of the Humanities Advanced Technology and Information Institute (HATII) at the University of Glasgow, serving as professor of Humanities Informatics and Digital Curation (1997-2008) and as Associate Director of the Digital Curation Centre in the UK (2004-2008). He is currently Dean of the Faculty of Information at the University of Toronto. His research focuses on digital preservation including work on preservation, repository design, digital library design and services, ingest, and semantic metadata extraction. Seamus has played key roles in several funded initiatives on digital libraries and preservation, acting as Principal Director of DigitalPreservationEurope (DPE) and a partner in Planets - Preservation and Long-term Access through NETworked Services. He was also a co-principal investigator in the DELOS Digital

Libraries Network of Excellence (2002-2008) and Principal Director of ERPANET, a European Commission activity to enhance the preservation of cultural heritage and scientific digital objects. Within DL.org, Seamus serves as a member of the Policy and Quality Working Groups.

### SARAH HIGGINS, DIGITAL CURATION CENTRE

Sarah Higgins is the Standards Advisor for the Digital Curation Centre (DCC). Based at the University of Edinburgh, she is responsible for the DCC DIFFUSE Project, which aims to document standards frameworks for a number of disciplines. She provides guidance and documentation regarding the use of standards applicable to digital curation, and comments, on behalf of the DCC, on emerging standards, or those undergoing revision. She recently coordinated the development of the DCC Curation Lifecycle Model. As a qualified archivist, Sarah's previous roles include: Metadata Coordinator for Edinburgh University Library, and Project Archivist, with responsibility for IT implementation, for both the Rebuilding the City Project and the NAHSTE Project at Edinburgh University Archives. Previously she was Geographic Information Research Officer for the British Antarctic Survey and Secretary to the UK Antarctic Place-names Committee. Sarah sits on the Executive Committee of the UK Society of Archivists Data Standards Group.

### GIUSEPPINA VULLO, UNIVERSITY OF GLASGOW

Giuseppina Vullo is a researcher at the Humanities Advanced Technology Institute (HATII), University of Glasgow. Her research interests range from quality to contextualisation in digital libraries and enhancement of special collections within digital environments. She was a DigitalPreservationEurope Exchange (DPEX) fellow at HATII in 2008, where she worked on digital collections assessment, applying Digital Repository Audit Method Based on Risk Assessment (DRAMBORA) and InterPARES 3 methodologies. She completed a PhD in Library Science and has previously worked in university libraries and international institutes in Italy and Switzerland.

### PASQUALE PAGANO, CNR-ISTI

Pasquale Pagano is a senior researcher at the Networked Multimedia Information Systems (NMIS) Laboratory of the Institute of Information Science and Technologies, National Research Council, Italy (CNR-ISTI). Dr Pagano has a strong background on digital library distributed architectures. He was one of the early developers of the ERCIM Technical Reference Digital Library (ETRDL) and has participated in the design of the most relevant DL systems developed by CNR, leading the design and development activity of the FP5 project SCHOLNET, designing the Virtual Library component in the FP5 project CYCLADES and participating in the design of the FP6 project DRIVER, and serving the DILIGENT

project as Technical Support Manager. He is currently the Technical Director of the D4Science project, and is also involved in DRIVER II and BELIEF II.

**COSTANTINO THANOS, CNR-ISTI**

**Session: Welcome Session**

Costantino Thanos is a research director currently affiliated to the Institute of Information Science & Technologies (ISTI), National Research Council of Italy. He graduated in Electronics Engineering at the University of Pisa and has been working at CNR-ISTI since 1970. His research interests include digital libraries, centralised/distributed multimedia databases, multimedia information retrieval and information engineering. He was the Scientific Coordinator of the DELOS Network of Excellence on Digital Libraries and has been the Scientific Coordinator of a number of EU-funded projects. He has served as Chairman as well as member of the Programme Committee of many international conferences

**GENEVA HENRY, RICE UNIVERSITY**

**Session: Reports & Visions from Content, Functionality and User Working Groups**

Geneva Henry is the Executive Director for Rice University's Digital Library Initiative, serving as the PI and Co-PI for a number of funded digital library projects and board member for several projects and organisations. Prior to joining Rice in 2000, she was a Senior IT Architect and Program Manager with IBM, where she was heavily involved in planning, managing, and architecting a number of digital library solutions for universities and museums world-wide, as well as for the U.S. Department of Defense.

**SEAMUS ROSS, UNIVERSITY OF TORONTO**

**Session: Reports & Visions from Policy, Quality and Architecture**

As above.

## 6.3 List of Participants

The participants of the DL.org workshop are listed below in alphabetical order.

| Name | Affiliation |
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|---|---|
| George Athanapoulos | University of Athens |
| Nina Avdeeva | Russian State Library |
| Federic Blanc | European Patent Office (EPO) |
| Rike Brecht | Ilmenau University of Technology |
| Leonardo Candela | National Research Council of Italy |
| Vittore Casarosa | National Research Council of Italy |
| Donatella Castelli | National Research Council of Italy |
| Tiziana Catarci | University of Rome, "Sapienza" |
| Schubert Foo | Nanyang University |
| Sillaume Ghislain | Virtual Resource Centre for Knowledge about Europe (Centre Virtuel de la Connaissance sur l'Europe - CVCE) |
| Stefan Gradmann | Humboldt University |
| Geneva Henry | Rice University |
| Sarah Higgins | Digital Curation Centre (DCC) |
| Perla Innocenti | University of Glasgow |
| Yannis Ioannidis | University of Athens |
| Akrivi Katifori | University of Athens |
| Georgia Koutrika | Stanford University |
| Ronald Larsen | University of Pittsburgh |
| Chunwang Li | Chinese Academy of Science |
| Paolo Manghi | National Research Council of Italy |
| Lori McCay-Peet | Dalhousie University |
| Anna Nika | University of Athens |
| Oddrun Pauline Ohren | Norwegian Archive, Library and Museum Authority |
| Joy Palmer | University of Manchester |
| Stephanie Parker | Trust-IT Services Ltd |
| Radoslav Pavlov | Bulgarian Academy of Science |
| Fausto Rabitti | National Research Council of Italy |
| Matthias Razum | FIZ Karlsruhe |
| Seamus Ross | University of Toronto |
| Mikhail Shvartsman | Russian State Library |
| Christina Catharina (Ina) Smith | University of Pretoria |
| Dagobert Soergel | University at Buffalo |
| Petr Sojka | Masaryk University |
| Maarten Steenhuis | Leiden University Library |
| Naimdjon Takhirov | Norwegian University of Science & Technology |
| Manfred Thaller | University of Cologne |
| Eleni Toli | University of Athens |
| Elaine Toms | Dalhousie University |
| Askiti Varsiliki | Bank of Greece |
| Julie Verleyen | National Library of the Netherlands |

| Giuseppina Vullo | University of Glasgow |
|---|---|

## 6.4 Workshop Interviews

Two videos were recorded during the 1st DL.org Workshop. The first interview was with Geneva Henry, Rice University and member of the project's External Advisory Board. The second interview was with Ronald Larsen from the University of Pittsburgh. The two interviews, which are available on the public website, are transcribed below. Several comments have been used as testimonials for the Workshop and the value-add of DL.org.

### Interview with Geneva Henry, Rice University, conducted by Yannis Ioannidis

**1) What is the value of adopting a single model for Digital Libraries?**

A common reference model for Digital Libraries would be a significant contribution to the community by providing a foundation for best practices and common standards as people are developing their Digital Libraries ad hoc and trying to figure out the right way to do it.

**2) Is there a need for interoperation between reference models in case we end up with two or three winners?**

In an ideal world it would be better to have one common model, but realistically it is not likely that we will have that. If we have multiple reference models that people are comfortable with, interoperability is really the key. If communities can work together to define that interoperability, then we could have something that is really valuable.

**3) How do you think DL.org will contribute to interoperability problems among Digital Libraries? Do you think we're moving in the right direction?**

DL.org is definitely moving in the right direction. It's tackling a problem that is huge and it's not easy to even begin to tackle all these issues on an interoperability level. When you start talking about policy, quality, users, architectures and functionality, all these areas require a tremendous amount of work, delving into and figuring out how they work together in a way that ensures Digital Libraries can talk together, exchange information and really be something for the end-users and where they do not have to worry about how it works.

4) **Do you see any concrete steps or initiatives that should be undertaken in that direction?**

I think that it's going to be really important for the work that is being done to coincide or somehow converse with significant efforts in other areas, such as the Framework Programme, which has been funded for a number of years and which is well along in their efforts. I am not sure if they deal with Digital Libraries but their work is valuable for the research and academic communities. It is important to build on what they have done and make them aware of the work within DL.org, so they can work that into their Framework activities.

5) **What is missing in the DL.org task list?**

Of the talks here today, there is not much focus on preservation or sustainability. In the eFramework, these issues are very important, so there could be beacons of additional efforts and plans to collaborate in this space.

### Interview with Ronald Larsen, University of Pittsburgh, conducted by Donatella Castelli

**1) What is the value of adopting a single model for Digital Libraries?**

To answer that question, I am going to draw on conversations during the Working Group interactions and activities that have truly inspired some valuable work within the information sciences and projects like TRAC and CLAY, which set out to conceive a fundamental model and fundamental approach that don't necessarily grab everyone's attention or best ideas but provide a sufficiently concrete direction that everyone is interested in, bringing about a competition where people can show what they can do in that space under those auspices. One of the things learned from TRAC, and I think also CLAY, is that it is not only the people funded and the communities they are dealing with that need to come to the table to participate in the conversations but others as well that want to demonstrate their capacity, such as corporations that say that they can do that and perhaps they can do it better than some of the universities. I think it requires something like a common reference model, a common statement, something that can grab the interest of the whole community and focus interests towards a particular domain. I think this is where the Reference Model comes into play.

**2) Do you see a real need for it?**

There is a strong need for it and if nothing else, we've learned from our conversations this afternoon and experience over the last ten years how complex this undertaking is, so I don't want to suggest this is a simple process but a dialogue since the DELOS Network of Excellence started, so it's incredibly complex and important, as we have pointed out today. The more we delve into it, the more rich and complex it is. It is incredibly important.

**3) How can DL.org work towards Digital Library interoperability?**

You've already pulled together the leaders in this space, particularly in Europe and particularly in the U.S., but there are people here today from Asia and South Africa, as well. I think that launching the conversation at places like this is incredibly important, providing opportunities for people to interact together. I was going through the DL.org pamphlet and listening to the talks this afternoon and this is by far the most comprehensive attempt yet to capture the whole space for DL research and development that needs to be done. I think it will become "the" forum for considering that.

**4) What concrete initiatives or steps should be undertaken?**

I think we learn an awful lot by doing. I know a lot of our conversation today has been thinking in the abstract, and this is an important piece, too. But unless we follow it up by doing, then we are doing ourselves a disservice. The question comes down to what we do and how we proceed. That's when the power of a reference model leveraged with other types of grand challenges and long-term opportunities comes into play, framed in a way that a large community can understand, along with the types of skills that are useful. So I think that DL.org now has a good sense of what the abstractions are through a wonderful and very complex reference model but very articulate in explaining what it is. So now the question is how do we take that very nice abstract work and map it into some of the things that are

being done today, like putting students on the task of analyzing projects already done and mapping them into the Reference Model would be useful. This would also be a very cheap way of doing it and students are always looking for great projects to do and could thus make a wonderful contribution. But then the next question needs to move beyond what is retrospective and look to the future, finding ways in which we can collectively engage the governments in the European Union and those in the U.S. towards larger-scale projects than perhaps we have tried before. We've had some level of success in collaborating projects particularly between Europe and the U.S. We need to find more ways of doing this. This is not going to be in Digital Libraries because we need to find another way to frame it, but the problems are so incredibly important and you've done such nice work in beginning to lay the foundations towards that. So we need to look both retrospectively and towards the future, to understand what kinds of projects we can pursue at this point.

**5) What is currently missing?**

The strength is the comprehensiveness of the abstract Reference Model. The next step is to take that and instantiate in a concrete way so we can better understand what it means in different contexts. So how would we take the quality discussion and map this into something very concrete that is not just a check list but a real enabler in the new developments just discussed. So instantiation is something we need to start talking about.