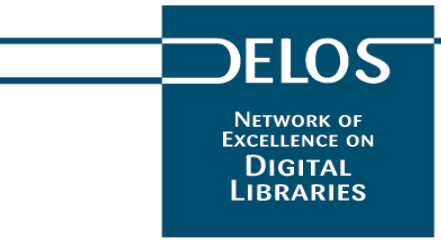


Project no.507618

DELOS

A Network of Excellence on Digital Libraries

Instrument: Network of Excellence

Thematic Priority: IST-2002-2.3.1.12

Technology-enhanced Learning and Access to Cultural Heritage

D9.1.7- Final Assessment of the NoE activities and their sustainability

Due date of deliverable: 31 December 2007
Actual submission date: 22 February 2008

Start Date of Project: 01 January 2004 Revision : Final
Duration: 48 Months

Organisation Name of Lead Contractor for this Deliverable: ERCIM

Project co-funded by the European Commission within the Sixth Framework Programme (2002-2006)

Dissemination Level: PU (Public)

Introduction

The following report is made of two documents produced in the last month of the DELOS life cycle, both summarising the activities and achievements of the network over its four years as an EC-funded project:

The first document is an **internal assessment** of DELOS. Edited and published by the Scientific Board, it describes the network structure, summarises the work performed and the results obtained by each work package, and highlights the major achievements of DELOS. This report is also available as a glossy brochure under the title "**Final Project Report**". It was published in December 2007 and was first distributed to the DELOS partners at the final DELOS conference in Pisa.

The second component of this final assessment is the **external report** that the **Scientific Advisory Board** produced after their last meeting with the DELOS Scientific Board at the December 2007 conference in Pisa. This report is a high level assessment of the achievements and influence of DELOS over the last four years, capturing the views of four internationally recognised independent experts in the field of Digital libraries.

Both documents provide an inside and outside view of what the DELOS Network of Excellence will be remembered for, as well as an insight on which sustainability activities should/will be implemented. On this particular subject, a more detailed sustainability plan can now be found in deliverable D11.2.5: DELOS Business Plan.

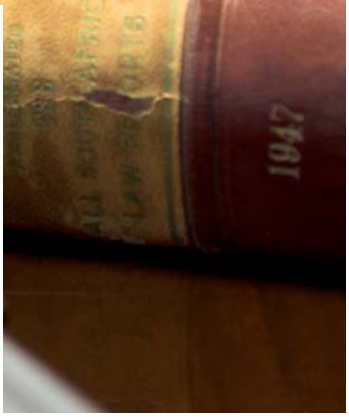
DELOS is a Network of Excellence on Digital Libraries, partially funded by the European Commission's Sixth Framework Program from 2004 to 2007.

The main objective of the DELOS Network of Excellence is to define and conduct a joint program of activities in order to integrate and coordinate the ongoing research activities of the major European research teams in the field of Digital Libraries for the purpose of developing the next generation Digital Library technologies.

This report summarizes the activities and achievements of the DELOS Network of Excellence over the four years of its EC-funded life time.

DELOS is a Network of Excellence co-funded by the European Commission

EC Project No : FP6-507618
Start Date: January 1st, 2004
Duration: 48 months
Total Project Cost: 15 700 000 euros
EC Funding: 6 000 000 euros
Further Information : http://www.delos.info/



Executive Summary

Concepts

Digital Libraries represent the meeting point of a large number of technical areas within the field of informatics, i.e., data management, information retrieval, document management, information systems, the web, image processing, artificial intelligence, human – computer interaction, mass- storage systems, and others. Moreover, Digital Libraries draw upon several other disciplines and fields beyond informatics, such as library sciences, museum sciences, archives, sociology, psychology, etc.

Digital Libraries first appeared as a concept in the early 1990s and grew up to become a discipline in its own right through many individuals projects that mostly focused on bridging some of the gaps between the constituent fields, understanding what "Digital Library functionality" is supposed to be, and integrating solutions from each field into systems that support such functionality.

Focusing specifically on the data and the users of information systems, an "information space" can be identified, in which one dimension represents the level at which users and tasks are predefined and known in advance, and the other dimension represents the level at which the data has (known) structure. Given this information space, Digital Library applications can be distinguished from typical Web and data base applications as shown in Figure 1.

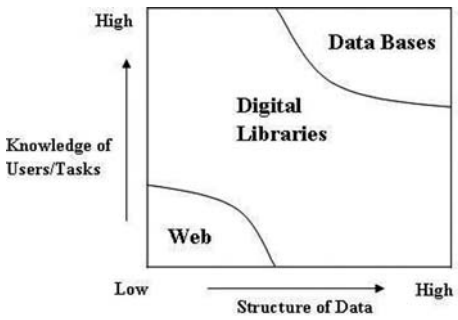


Figure 1: Digital Libraries positionning

Typical Web search engines assume very little about users, tasks, and the data they deal with, and so they occupy a relatively small part of the information space, as shown the lower left corner of the figure. On the other hand, in general, database applications assume a great deal about users, tasks, and data, and therefore these applications also occupy only a small part of the space, in the upper right corner.
The remaining information space can be viewed as belonging to Digital Library applications. In this part of the space, information systems attempt to exploit knowledge about the users, tasks, and domain to improve access, but retain the flexibility of ad-hoc querying, filtering, presentation, etc. that is characteristic of many Web-based applications. This mixture of characteristics leads to many unique research challenges and interesting test-bed applications.

Activities

The activities of DELOS, in a broad meaning, started many years ago, with the DELOS Working Group at the end of the nineties, and the DELOS Thematic Network, under the Fifth Framework Programme, from 2001 to 2003.

DELOS has played a significant role in:

- the formation of an active European Digital Library research community,
- the formulation of a vision for the future of the field,
- fostering collaborative research in the direction of this vision.

Indeed, DELOS has had considerable success in stimulating European research activities and promoting the building up of expertise in DL-related fields in order to maintain European R&D in this important area at a globally competitive level. In particular, DELOS has played an important role in the creation of a European Digital Library research community. It has succeeded in mobilizing in its activities almost all the active European research teams in the Digital Library field. Currently, there are 56 members of DELOS from 15 European countries. These include the major European research centers in informatics (INRIA, Fraunhofer, CNR, CWI, SICS, FORTH, MTA SZTAKI), 37 European university departments and four representatives of interested application domains.

Ultimately, DELOS envisions systems with no logical, conceptual, physical, temporal, or personal borders or barriers on information. The DELOS vision is that Digital Libraries will become the universal repositories and communication conduits for the future, common vehicles by which everyone will access, analyze, evaluate, enhance, and exchange all forms of information. They will be indispensable tools in the daily personal and professional lives of people. They will be accessible at any time and from anywhere, and will offer a friendly, multi-modal, efficient, and effective interaction and exploration environment. The DELOS Network of Excellence aims at advancing the state of the art in the field so that a first version of the vision may become reality by the end of the decade.

The DELOS Network of Excellence on Digital Libraries has initiated a long journey towards filling the gap between current Digital Library practice and the needs of modern information provision. Its goal is to foster the development of technology that will eventually overcome the current restrictions of today's systems and empower every one to further advance their knowledge, profession, and role in society.

The DELOS research activities are organized around the following main themes that have been identified as critical for realizing its vision (see Figure 2):

Foundational research

- Reference Model for Digital Library Systems

Systems-related research

- Digital Library System Architectures
- Information Access to Digital Libraries
- Audio/Visual Digital Libraries
- Semantic Interoperability in Digital Libraries

User-related research

- User Interfaces for Digital Libraries
- Digital Library Visualization
- Personalization in Digital Libraries

Horizontal issues

- Digital Library Curation and Preservation
- Digital Repositories
- Digital Library Evaluation Methodologies
- Digital Library Evaluation Infrastructures

From the management point of view the DELOS activities are organized around eight work-packages:

Digital Library Architecture
Information Access and Personalization
Audio/Visual and Non-Traditional Objects
User Interfaces and Visualization
Knowledge Extraction and Semantic Interoperability
Digital Preservation
Digital Library Evaluation
Dissemination and Technology Transfer

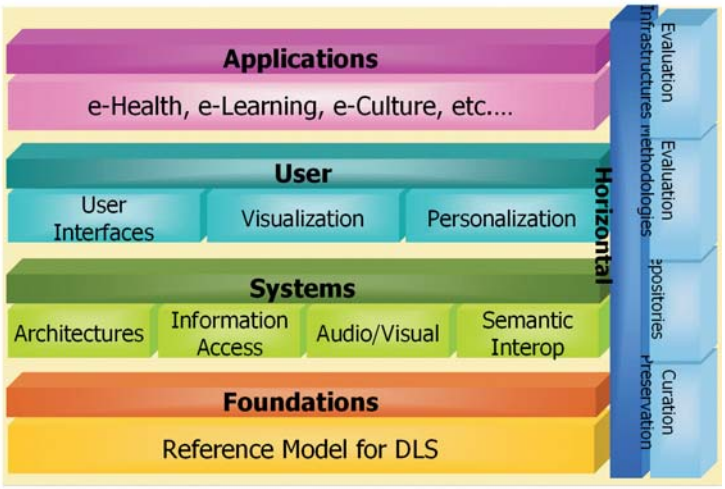


Figure 2: DELOS research themes

Achievements

The achievements of the Network during its life can be classified into four broad categories: (a) achievements related to spreading excellence and disseminating research results to the interested application communities, and training the young researchers in digital library related themes, (b) achievements related to advancing the state-of-the-art in a number of technologies which are crucial for the development of the next generation of digital libraries (c) the definition of a reference model for digital libraries and (d) the development of DelosDLMS, i.e., a globally integrated prototype and demonstrator system for future Digital Library Management Systems.

The following achievements belong to the first category:

- DELOS Web site
- DELOS Digital Library
- DELOS Exchange Program
- DELOS Thematic Workshops
- DELOS Summer Schools
- DELOS Conferences

The following results fall into the second category:

- Production of a large number of scientific papers reporting research results achieved by the DELOS members;
- Development of demonstrators related to the research objectives of the Network;
- Theoretical work related to the development of models related to the research activities of the Network;
- Development of infrastructures to support large evaluation campaigns in the field of Cross-Language Retrieval and XML retrieval.

The DELOS Reference Model

The DELOS Reference Model has set the foundations and identified the entities of discourse within the universe of digital libraries. It has introduced the relationships among three kind of relevant systems in this area: Digital Library, Digital Library System, and Digital Library Management System. It has presented the main concepts characterizing the above, i.e. content, user, functionality, quality, policy, and architecture, and has identified the main roles that actors may play within a digital library, i.e end-user, designer, administrator, and application developer. Finally, it has described the reference frameworks that are needed to clarify the digital library universe at different levels of abstraction, i.e the Reference Model, The Reference and Concrete Architectures.

The DELOS Digital Library Management System – DelosDLMS

The DelosDLMS is the globally integrated prototype and demonstrator system for future Digital Library Management Systems. This system combines text and audio-visual searching, offers personalized browsing using new information visualization and relevance feedback tools, allows retrieved information to be annotated and processed, integrates and processes sensor data streams, and finally, from a systems engineering point of view, is easily configured and adapted while being reliable and scalable. The prototype is built by integrating digital library functionality provided by the DELOS partners into the OSIRIS/ISIS platform, a middleware environment developed by ETH Zürich and now being extended at the University of Basel. The result of the integration – that is, the middleware infrastructure together with all the advanced DL functionality – constitutes the DelosDLMS, i.e., the final DELOS milestone.

Now that DELOS has reached the end of the funding period, there are definite plans to establish a DELOS Association that will help to ensure the continuity and the sustainability of the "DELOS spirit" in the future.

DELOS Scientific Coordinator

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ISTI-CNR

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Contents

DELOS Structure

DELOS Scientific Board

The Scientific Board receives guidance from the Advisory Board and provides a high level supervision of the network's integration and research activities. It promote and assess the scientific quality of the network, define means to implement all major technical decisions, define funding policies, identify the need for significant changes in the Network of Excellence work-plan and oversees their implementation. The Board is composed of the Scientific Coordinator of the Network and the Work Package Leaders. The Administrative Coordinator is also attending the meeting of the Scientific Board to guarantee coordination between scientific and integration activities and the necessary administrative back-up actions.

DELOS Scientific Co-ordination
Constantino Thanos
Consiglio Nazionale delle Ricerche, Pisa

DELOS Administrative & Financial Management
Bruno Le Dantec / Philippe Rohou
European Research Consortium for Informatics and Mathematics

Cluster Coordination: AudioVisual and Non-traditional Objects
Stavros Christodoulakis Technical University of Crete
Alberto Del Bimbo Università degli Studi di Firenze

Cluster Coordination: User Interfaces and Visualisation
Tiziana Catarci
Università di Roma "La Sapienza"

Cluster Coordination: Digital Library Evaluation
Norbert Fuhr
Universität Duisburg-Essen, Germany

Cluster Coordination: Digital Library Architecture
Hans-Jörg Schek
University of Konstanz and Emeritus of ETH Zurich

Cluster Coordination: Information Access and Personalization
Yannis Ioannidis
University of Athens

Cluster Coordination: Knowledge Extraction & Semantic Interoperability
Elizabeth Lyon
University of Bath, UK

Cluster Coordination: Preservation and Curation
Seamus Ross
University of Glasgow and ERPANET

Cluster Coordination: Dissemination & Spreading of Excellence
Vittore Casarosa
Consiglio Nazionale delle Ricerche, Pisa

DELOS Structure

DELOS Advisory Board

With respect to the Scientific Board, the Advisory Board's role is threefold:
- it provides external assessment of the results achieved by the network, acting as a peer-review council;
- it provides guidance with respect to the network's strategic orientations;
- it provides support of the network's excellence.

The board is composed of senior external experts in the field, nominated by the Scientific Coordinator of the Network, in agreement with the Commission. The independent experts of the board are required to make an annual assessment of the results achieved during the preceding year and the activities planned for the successive year of the Network, and to provide recommendations for improving the network's efficiency and excellence. The Advisory Board meets annually in order to review the activities and achievements of the Network, based on the activity reports, the deliverables produced and the milestones achieved during the previous year. The Scientific Board is invited to attend part of the meeting and present a report on the "state of the network", containing a self-assessment of the network activities and the perceived or potential problems. The results of the Advisory Board review are given in a written report.

John Mylopoulos
Professor, Department of Computer Science, University of Toronto, Canada
Visiting Professor, Department of Informatics and Telecommunications, University of Trento, Italy

Edward A. Fox
Director of DLRL - Digital Library Research Laboratory, Virginia Tech
Professor, Department of Computer Science, Virginia Tech, USA

Steve Griffin
Program Director, Digital Library activities
NSF Computer and Information Sciences and Engineering Directorate, Arlington, USA

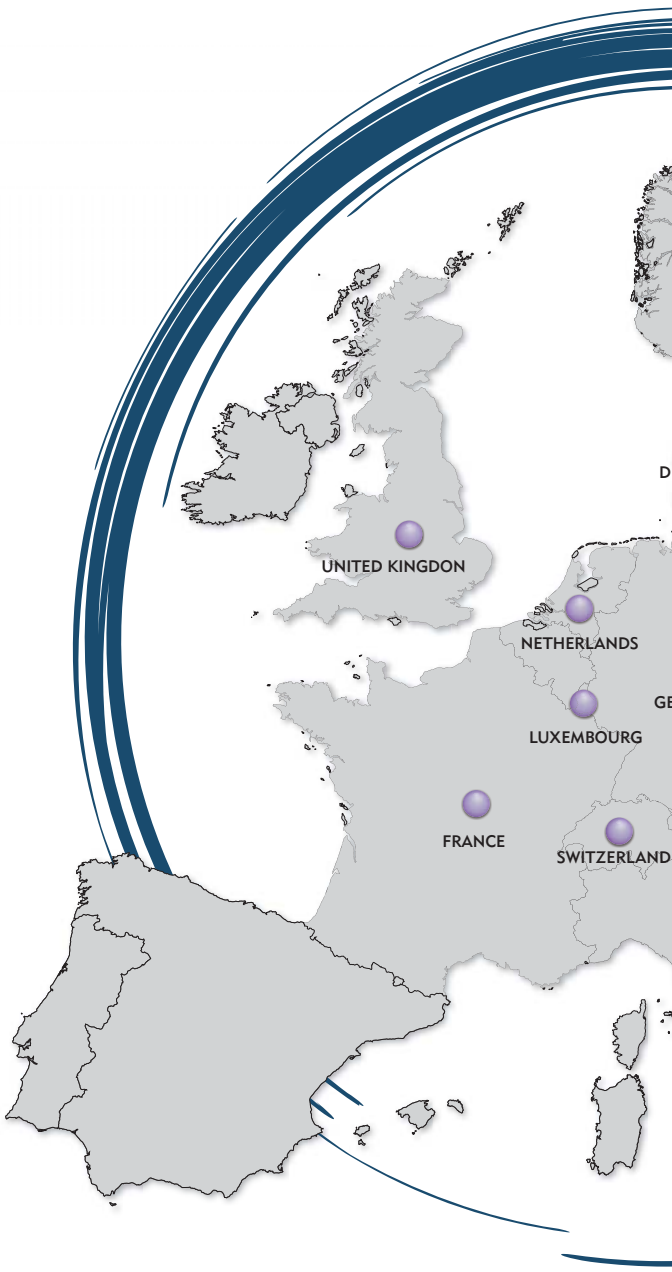
Keith Van Rijsbergen
Professor and leader of the Information Retrieval Group,
Department of Computing Science, University of Glasgow, UK

DELOS Consortium

59 Research Centres & Universities
From 15 countries

GEIE-ERCIM	ERCIM	France
Consiglio Nazionale delle Ricerche	CNR-ISTI	Italy
Eidgenössische Technische Hochschule Zurich	ETH Zurich	Switzerland
University of Bath	UKOLN	UK
National and Capodistrian University of Athens	UOA	Greece
Technical University of Crete	TUC	Greece
Università degli Studi di Firenze	UNIFI-MICC	Italy
Fraunhofer-Gesellschaft zur Förderung der Angewandten Forschung	FHG/IPSI	Germany
University of Glasgow	GU	UK
Universität Duisburg-Essen	UNIDU	Germany
Stichting Centrum voor Wiskunde en Informatica	CWI	Netherlands
Risoe National Library	RISOE	Denmark
Foundation for Research and Technology – Hellas	FORTH	Greece
Università degli Studi di Roma "La Sapienza"	ROMA1	Italy

Institute of Communication and Computer Systems	ICCS	Greece
Università degli Studi di Padova	UNIPD	Italy
Università degli Studi di Milano	UNIMI	Italy
Institut fuer Medizinische Informatik und Technik Tyrol	UMIT	Austria
Max-Planck-Gesellschaft z.F.d.W. represented by: MPI für Informatik	MPII	Germany
Kuratorium OFFIS E.V.	OFFIS	Germany
Queen Mary & Westfield College, University of London	QMUL	UK
University of Strathclyde	USG	UK
Ionian University, Archive and Library Science Department	IU	Greece
Université Paris-sud XI	UPSXI	France
The University of Southampton	UOS	UK
The University of Edinburgh	UEDIN	UK
Institut für Informationsverarbeitung und Computergestuetze Neue Medien	IICM	Austria



Technische Universität Wien	TUW	Austria
Universita' degli Studi di Urbino Carlo Bo	UNIURB	Italy
Norges Teknisk-Naturvitenskapelige Universitet	NTNU	Norway
Lunds Universität	ULUND	Sweden
Institut National de Recherche en Informatique et en Automatique	INRIA	France
Aristotle University of Thessalonikis	AUTH	Greece
Nationaal Archief	NANETH	Netherlands
Univesität Bremen	TZI	Germany
Österreichische Akademie der Wissenschaften	OEAW	Austria
Universität zu Köln	UCO	Germany
Forma (Centro di) Formazione e Ricerche per Metodologie Applicate alla Conservazione, Gestione e Comunicazione di Beni Culturali	CF	Italy
Swedish Institute of Computer Science AB	SICS	Sweden
Universita' di Modena e Reggio Emilia	UNIMORE	Italy
Masaryk University Brno	MUNI	Czech Republic
Universiteit van Amsterdam	UVA	Netherlands
Università della Svizzera Italiana	UNISI	Switzerland

Magyar Tudomanyos Akademia Szamitastechnikai es Automatizalasi Kutatointezet	MTA SZTAKI	Hungary
Università degli Studi di Bari – Dipartimento di Informatica	UNIBA	Italy
Health Information Technologies Tyrol	HITT	Austria
Lancaster University	UoLanc	UK
Athens University of Economics and Business	AUEB	Greece
University of Glamorgan	UGLAM	UK
University of Queensland	Uqueensland	Australia
Austrian National Library	OENB	Austria
Göttingen State and University Library	SUB	Germany
Imperial College	Imperial	UK
Institute of Knowledge Sharing	IKS	Denmark
Center of Cognitive Systems Engineering	CSE	Denmark
Centre Virtuel de Connaissance sur l'Europe	CVCE	Luxembourg
Universite de Lille	USTL	France
University of Konstanz	UKON	Germany
University of Basel	UNIBAS	Switzerland

DELOS Clusters

The research activities of the Network are organised in a set of Workpackages or Clusters

WP1 Digital Library Architectures

More and more digital libraries require a common infrastructure, which must be highly scalable and customizable. A synthesis of concepts and techniques from peer-to-peer data management, grid computing middleware, and service oriented architectures can help to achieve this goal. Standards and protocols play a major role in this field.

WP2 Information Access and Personalisation

Information access topics in focus include comparison and integration of diverse data models and query processing schemes, metadata models, data provenance and annotation, and processing of specialised data forms. Aspects of personalisation being studied include user modeling, user profiling, and several schemes of personalisation.

WP3 Audiovisual and non-traditional objects

Digital libraries are more and more containing large amounts of digital information in the form of video, audio and images. The main objectives of this cluster are to investigate the area of metadata capturing from audiovisual content and to establish common foundations in the areas of information access, interaction and management of audiovisual content.

WP4 User Interfaces and Visualisation

The activities are focusing on issues of user requirements, such as characterisation of DL users and analysis of user-related aspects in the development and usage of DL systems, as well as issues related to the design of user interfaces and visualisation, such as the development of a taxonomy of relevant context models, the development of a comprehensive model for relevance criteria and the development of a theoretical framework for DL user interface design.

WP5 Knowledge Extraction and Semantic Interoperability

A programme of activities that coordinates research from a range of inter-related knowledge engineering and iinformation management areas is being undertaken in order to facilitate the sharing of experience and expertise amongst practitionners with a background in computer science, DL, and Grids. New models, algorithms and methodologies are being studied, together with the production of best practice guidelines and recommendations.

WP6 Preservation

This cluster is promoting and coordinating research activities in order to create a platform for proactive collaboration, exchange and dissemination of research results and experience in the preservation of digital objects. Efforts are on going to ensure that this work has a direct impact on the digital library architecture and the development work of other clusters in the DELOS Network.

WP 7 Evaluation

Existing resources for DL evaluation are being collected in order to develop DL evaluation methodologies and new models and techniques. Evaluation toolkits and new testbeds are being created, capitalising on evaluation initiatives such as CLEF (Cross Language Evaluation Forum) and INEX (Initiative for the Evaluation of XML retrieval).

DELOS Clusters

Digital Library Architecture

Objectives

The overall goal of this work package is to analyze, develop, and integrate architectures and technology for digital libraries that enable the building of the next generation digital library management systems. Two DELOS "horizontal" tasks are active in this work package, namely, first, the establishment of the Digital Library Reference Model Document and, second, the development of a globally integrated prototype for future Digital Libraries, the DelosDLMS demonstrator. The ambitious objective is to have two main DELOS "products", namely a foundational reference document and a sophisticated concrete demonstrator for future digital library management systems. These two activities – according to their horizontal nature – are described separately. Complementary to these activities we investigate further architectural issues in the context of annotations, distributed health digital libraries and inclusion of data stream processing in three tasks that are described in the following.

Activities

Design, Implementation and Evaluation of Multimedia Annotations for User Collaboration

The main goal of this activity is the architectural design, development, and evaluation of a digital library annotation service. Annotations are a way of explaining and enriching an information resource with personal observations. In addition, they are also a means of transmitting and sharing ideas to improve collaborative work practices.

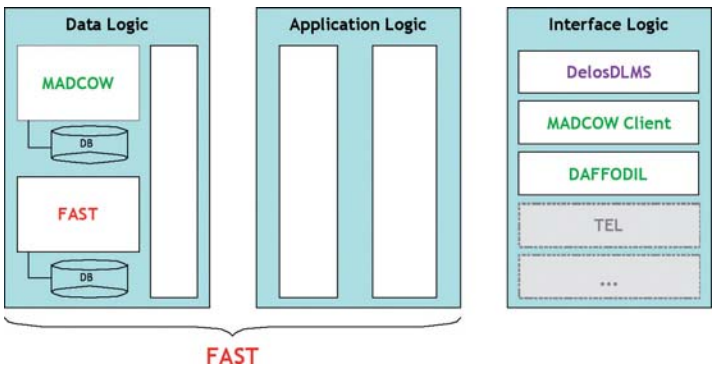


Fig. 3.1 The annotation architecture layers

Management of and Access to Virtual Electronic Health Records

eHealth Digital Libraries contain electronic artefacts that are generated and managed by different healthcare providers. The electronic health record of patients therefore consists of a set of distributed artefacts and cannot be materialized for organizational reasons. It is a virtual entity and has to be generated by composing the required artefacts each time it is accessed. The eHealth DL has to allow for the transparent and efficient access to distributed data. An example is content-based similarity search across a potentially large set of multimedia documents (see Figures 3.2 and 3.3).

Figure 3.2: ISIS: content-based retrieval of medical images

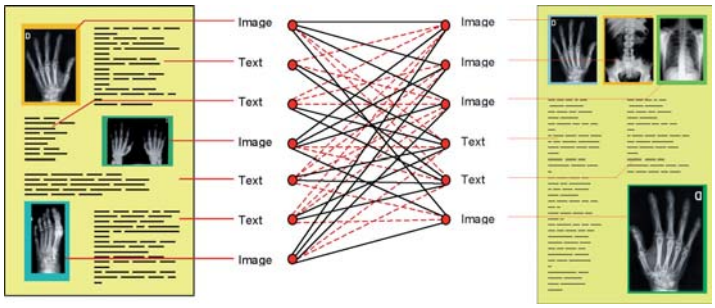


Figure 3.3: Composite object similarity search in multimedia electronic health records

Integration of Reliable Sensor Data Stream Management into Digital Libraries

Data Stream Management (DSM) addresses the continuous processing of sensor data and requires the combination of stream operators, which may run on different distributed devices. In order to efficiently deal with the increasing amount of streaming information, Digital Library (DL) systems have to merge with DSM systems. Especially in healthcare, the continuous monitoring of patients at home (telemonitoring; see Figure 3.4) will generate a significant amount of information to be stored in an eHealth digital library (electronic patient record). Vice versa, vital decisions have to be made on the basis of information from the electronic patient record.

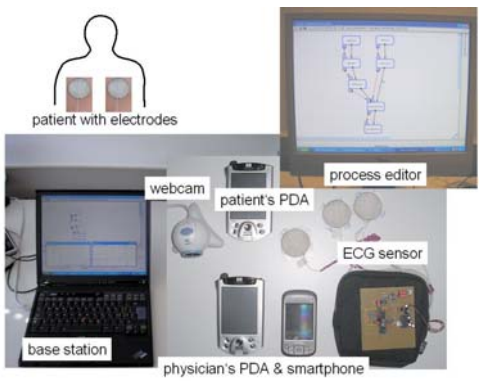
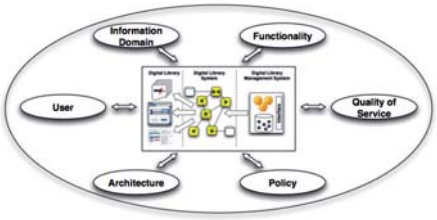


Figure 3.4 Data Stream Demonstrator Setup

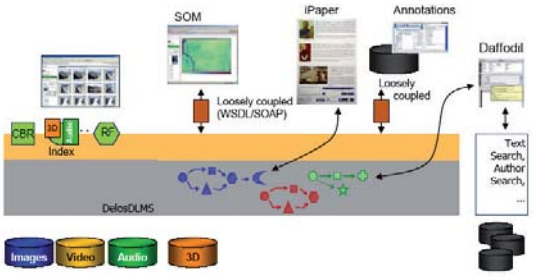
Results

Key results of the Architecture Cluster are:

The Reference Model for Digital Libraries



The DelosDLMS globally integrated prototype



Both activities are described in detail on pages 28 to 33.
Further results include

- Two workshop proceedings
- A survey that collects most significant contributions of peer-to-peer data management, grid computing, and service-orientation for digital library architectures
- A prototype that combines data stream processing with conventional workflow execution
- A report on standards and protocols
- A prototype system on annotations
- A report on mobile information management
- A report on distributed health record management

Cluster Leader:

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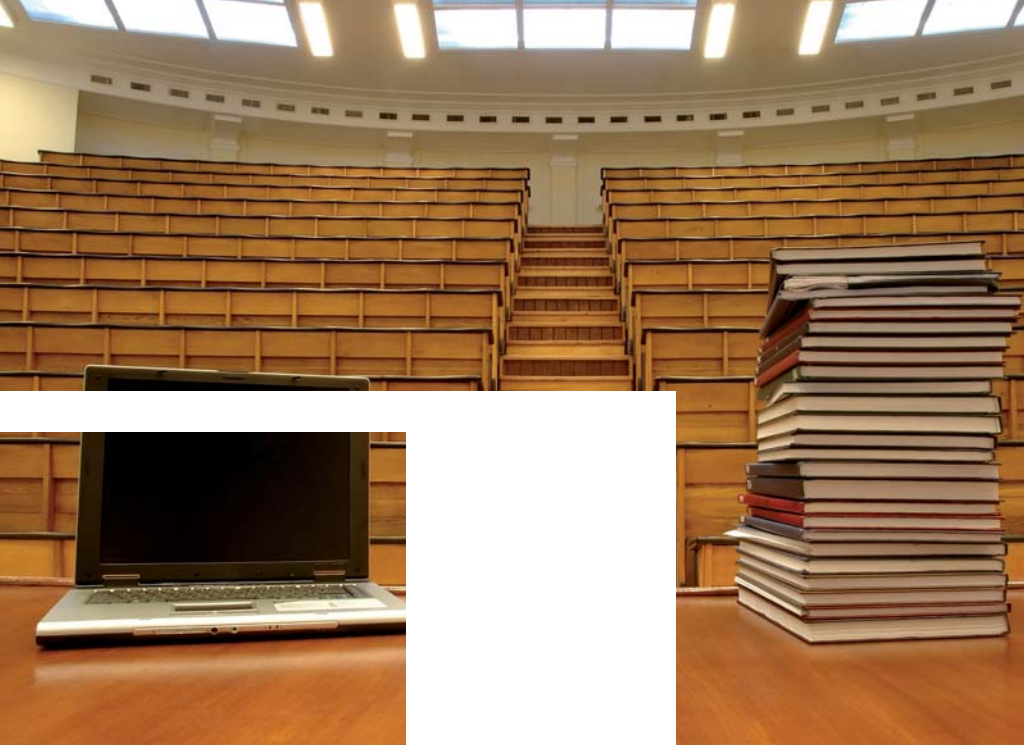


DELOS Clusters

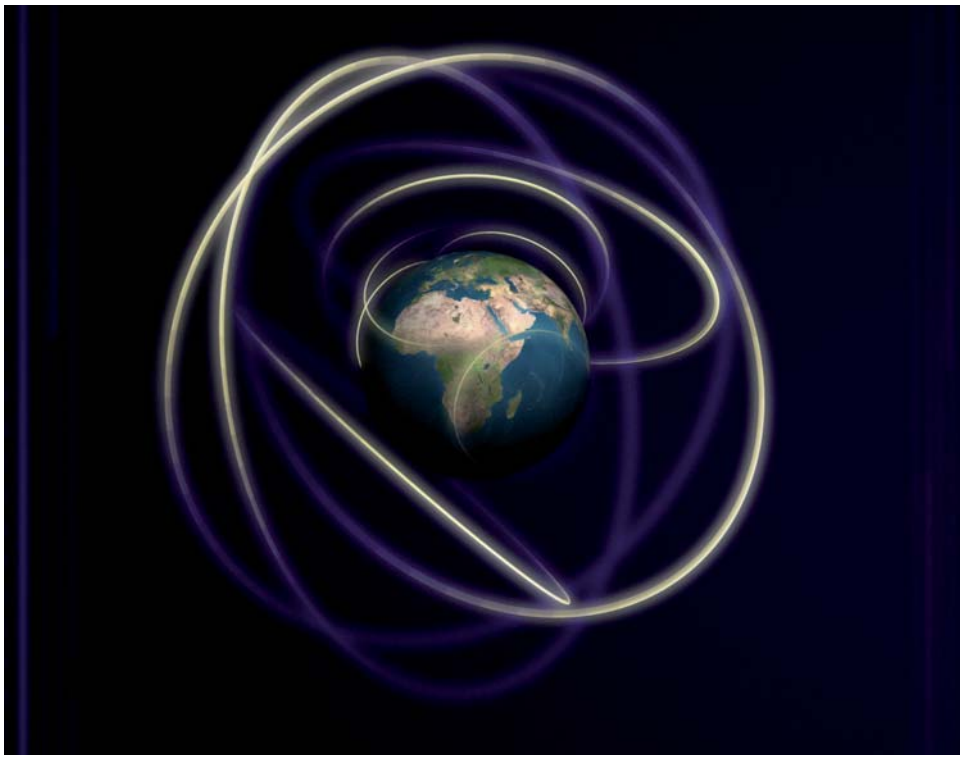
Information Access and Personalisation

Information stored in digital libraries needs to be accessed, integrated and individualized for any user, anytime and anywhere in possibly multiple, comprehensive and efficient ways.

Objectives

Within the DELOS Network of Excellence, Information Access in Digital Libraries is studied from three different aspects:

- **Information Access:** interaction with a single information provider. Information stored in a source comes in different types and formats, each one with its own characteristics and particularities. Organization of data within an individual source and efficient and effective search are the key issues and are actually highly interrelated to each other. Different approaches exist but there is a general trend towards richer representations and languages both at the structural and at the semantic level.
- **Information Integration:** interaction with multiple information providers. Integrated access of different sources presents special problems due to information heterogeneity, redundancy etc. Issues such as source selection and results fusion must be considered under different possible settings. Data provenance is often crucial to the trust that is placed in data, hence it should be managed based on sound formulation.
- **Personalization:** customization of information and interaction with the user. Different users have different characteristics and preferences concerning the information they are interested in seeing when accessing a digital library. Even users sharing a common information need may expect different results, different functionality or different interface. Moreover, the relevant contents and interface of a digital library may be dependent on other factors as well, e.g. device or network-specific.



The cluster objectives with respect to the aforementioned aspects are the following:

1. Promotion of knowledge about available practices in the fields of information access and personalization. This will lead to a uniform understanding of problems among researchers.
2. Construction of a common, comprehensive framework for information access and personalization. This framework is intended to serve as a reference point for the DL area and to stimulate research.
3. Promotion of research on new information access and personalization models and methodologies.

Activities

The cluster activities with respect to information access, integration and personalization are very coarsely organized into the following categories:

- Collection, study and comparison of models, languages and algorithms for data, metadata, and queries with respect to information access and integration
- Collection, study and comparison of user-profile models and various forms of content and interaction personalization
- Integration of the most effective approaches to information access and personalization and derivation of new ones
- Development of toolkits and systems for purposes of re-use and demonstration of proposed methods and models

Results

The results of the above activities include the provision of theoretical frameworks and understanding concerning the three major problem areas of the cluster's charter, i.e., Information Access, Information Integration and Personalization. The aforementioned activities have promoted the cooperation among individual research groups leading to the development of prototype systems and toolkits with the purpose of integration, improvement and evaluation of existing approaches. Finally novel techniques have been devised, advancing the state of the art in the respective areas and resulting in numerous publications.

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DELOS Clusters

Audio-visual and non-traditional objects

Digital libraries often store non-traditional content, such as images, sound, video, graphics, etc. which typically is highly structured into segments and/or semantic units (objects). Such content is bound to have significant impact in the knowledge society. For the effective support of applications on top of Audiovisual Digital Libraries, multimedia content needs to be indexed and interconnected in a variety of ways allowing flexible access, transcoding, browsing, semantic integration, presentation, and personalization according to the application functionality, the domain of knowledge described, the presentation device and the user's preferences and goals. Effective and user-centered access methods to this highly-structured content influence the spread and hence the impact of Audiovisual Digital Libraries in the knowledge society.

Objectives

The overall research objective for the audiovisual and non-traditional objects cluster of Delos is to formalize and develop a complete framework to support Semantically-Enabled Audiovisual Digital Libraries. Core research directions for the accomplishment of this framework include:

- **Metadata Capturing and Management for Audio-Visual Content:** Metadata capturing for audiovisual content is an important functionality in order to allow effective indexing and retrieval for the audiovisual and non-traditional objects stored in digital libraries. Since these objects may be used in some particular application domain (e.g. biology, sports, politics, etc.), domain specific annotation is of high importance in order to provide effective support of the digital library applications. This research direction aims at providing a uniform framework that allows content, structural, and domain specific semantic metadata for audiovisual content to be captured (both manually and automatically).

- **Universal Efficient Access and Interactions with Audiovisual Libraries:** In Semantically-Enabled Audiovisual Digital Libraries, knowledge and content acquisition is of major importance. In such an environment where highly structured and complex indexing and annotation is applied, traditional interfaces are particularly inflexible and difficult to use. This research direction aims at addressing this issue by investigating formal frameworks, languages, and methodologies for multimodal access to knowledge and content stored in audiovisual digital libraries. Natural Language (NL) and Speech Interfaces to semantically annotated audiovisual content represent significant research directions in this area.

- **Adaptation and Personalized Presentation:** Customization and presentation of information according to user or contextual information is very significant for audiovisual digital libraries due to the nature of the audiovisual content (audio, visual, images, etc.), for the purpose of retrieval, synthesis, presentation, compressed transmission, etc. This research direction aims at developing frameworks and methodologies which can be applied in DL infrastructures in order to enable adaptation and personalized presentation of multimedia content.

Activities

The cluster activities with respect to audiovisual aspects of digital libraries can roughly be classified under the following categories:

- Investigation, research and development of frameworks, models, and methodologies, for incorporation of domain specific knowledge into audiovisual metadata capturing process, as well as exploitation of this knowledge in indexing and retrieval of audiovisual and non traditional objects.
- Investigation, study and development of approaches, methodologies and algorithms to automatically annotate and classify audiovisual content from both semantic and technical perspective.
- Collection, study, and development of formal methodologies for natural language and speech based knowledge and content acquisition from Semantically-Enabled Audiovisual Digital Libraries exploiting ontology conceptualizations.
- Study and development of methodologies and techniques for personalized multimedia presentation authoring and generation by applying adaptation (transformation, transcoding) of audiovisual content based on semantic and technical contextual information.

o Development of toolkits and prototype systems as proof-of-concept for the results of the aforementioned research activities.

o Service-Oriented deployment and integration of such prototype systems into large scale Digital Library Management Systems (DLMS)

Results

The results so far of the above research activities include:

- Establishment of a common understanding and vision among European research groups for the matters pertaining to audiovisual aspects of digital libraries.
- Theoretical frameworks and methodologies for the three major research areas of the cluster's theme (i.e. Metadata Capturing and Management for audiovisual and non traditional content, Universal Efficient Access and Interactions with audiovisual digital libraries, Adaptation and Personalized Presentation of audiovisual and non-traditional content).
- Prototype toolkits and integrated demonstrators that evaluate the applicability of the invented theoretical frameworks and methodologies.
- Integration of various prototypes into the Delos DLML as building blocks (services) of a convergent large scale Digital Library Management System.
- Formal architectural design patterns to effectively support the audiovisual aspects of the future digital libraries have been devised based on the experiences gained from the development and evaluation of the aforementioned prototypes.

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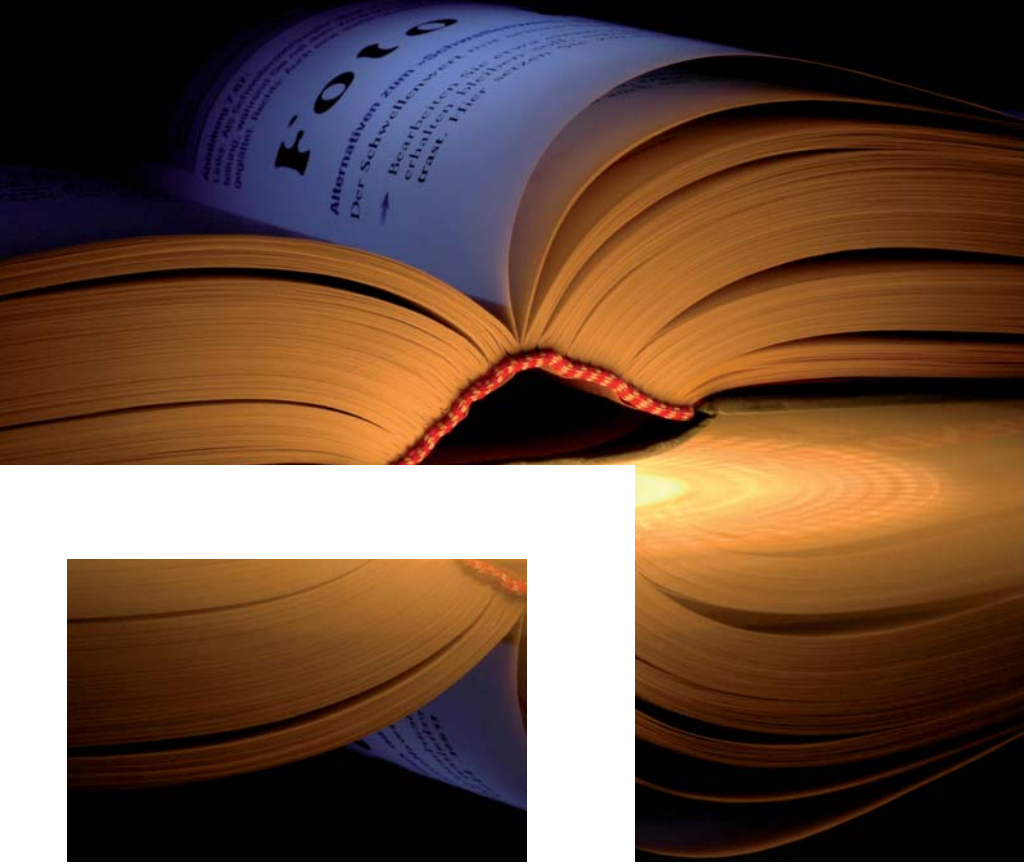


DELOS Clusters

User Interface and Visualisation

Working together to really place the user at the center of the information environment through careful requirement collection, appropriate design and effective evaluation. The ultimate goal of the User-Interface and Visualization cluster is to develop methodologies, techniques and tools to establish a theoretically motivated and empirically supported frame of reference for designers and researchers in the field of user interfaces and visualization techniques for digital libraries, so to enable future DL designers and developers to meet not only the technological, but also the user-oriented requirements in a balanced way.

Objectives

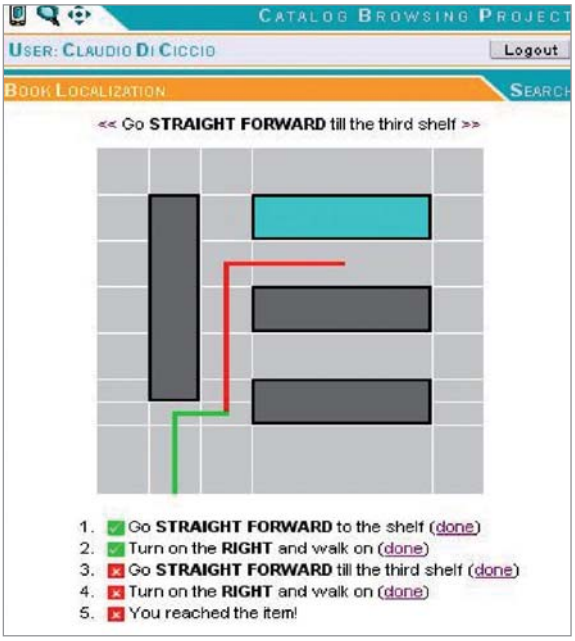
Specific objectives of the cluster are:

- To elaborate a common understanding of the role and scope of user interface research in the digital library area,
- To develop a theoretical framework for digital library user interface design,
- To develop user-centered methodologies, techniques and tools to be exploited by DL designers and developers.

Activities

The cluster activities with respect to user interfaces and visualization mainly deal with:

- Collection and analysis of the user requirements for a DL interface that could provide support to all kinds of users throughout the entire DL lifecycle,
- Design, collection, study, comparison, and matching against user requirements and DL lifecycle phases, of various forms of interaction paradigms, both visual and non-visual,
- Design, collection, study, and comparison of tools and techniques exploiting visual clues in making sense out of information,
- Integration of the most effective interaction paradigms and visualization approaches and derivation of new ones,
- Development of toolkits and systems for purposes of re-use, testing, and demonstration of proposed methods and models.



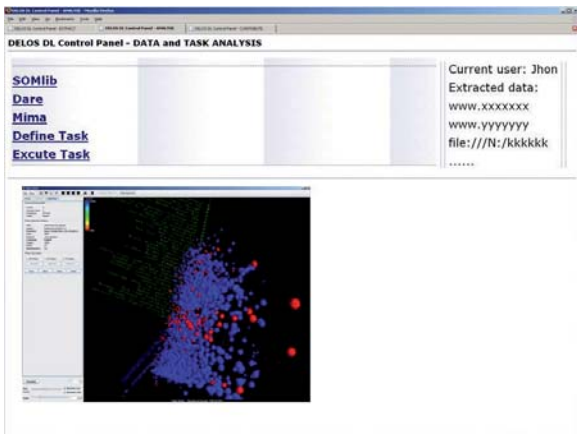


Figure 4: Examples of User Interface and Visualisation

Results

Initial cluster results concentrated mainly on the understanding of the role and scope of DL user interface research and the investigation of the user requirements for a DL interface design that provides support to all users throughout the entire DL lifecycle. Based on this foundation, the cluster is producing a design framework and interaction model, based on the revised lifecycle model and equipped with concrete examples of suitable interaction paradigms, both visual and non-visual, e.g., natural-language based. The design framework also comprises innovative task-oriented interaction mechanisms, novel visualizations, and advanced functionalities, such as collaboration support, automatic linking, recommendation, visual exploration and enrichment of the available information. The specific component prototypes have been evaluated against real users and some of them have been integrated in the Delos reference architecture, thereby offering an example of innovative DL interface developed on the basis of the Delos frame of reference.

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DELOS Clusters

Knowledge Extraction and Semantic Interoperability

The KESI cluster, which includes EU partner representatives and global collaborators from Greece, Italy, Sweden, UK and Australia, has carried out research in a number of inter-related technical areas. The cluster has also worked across sectors, using educational and cultural heritage content to test the software tools and demonstrators under development. The themes of this cluster cover some of the most challenging areas in digital library development, namely achieving effective semantic search and interoperability between heterogeneous systems and content. This has been investigated from both a theoretical viewpoint, by examining and developing abstract models, but also from a practical perspective, through building demonstrator systems and testing the concepts in real-world situations, ranging from e-learning contexts to built-heritage ontological frameworks. In addition, aspects of digital repositories, bibliometrics and associated knowledge extraction methodologies, have been evaluated in a series of reports and workshops.

Objectives

Over the four years of the DELOS network, the KESI cluster has worked towards a number of high-level strategic objectives:

- To carry out foundation work describing the state-of-the art in the three initial task areas of digital repositories, knowledge extraction and semantic interoperability;
- To work more closely with e-Learning and cultural heritage user communities in the design, testing, evaluation and enhancement of the prototype systems and to facilitate their integration with the DELOS Digital Library;
- To extend the functionality of the GraphOnto tool and promote its application and use in other DELOS research tasks as an exemplar of integration within the network;
- To investigate and develop methods and a demonstrator, for the integration of heterogeneous data types, models, upper level ontologies and domain specific Knowledge Organisation Systems (KOS).

Activities

Digital Repositories & Open Archives

Work has focussed on collating and sharing evidence and research experience of digital repositories, covering the range of learning and research applications. The volume of global development work in this area has grown rapidly during the DELOS timeframe e.g. the major Digital Repositories Programme launched by the JISC in the UK, FEDORA, DSpace and ePrints.org activities, and more recently the OAI-ORE specifications. Newer EU-funded initiatives such as DRIVER Digital Repository Infrastructure Vision for European Research (building a network of European repositories), have demonstrated the critical importance of this research area.

Knowledge Extraction

This activity has concentrated on bringing together the knowledge and experience of cluster partners in the general field of knowledge-based research. Knowledge engineering technologies including knowledge extraction, ontologies and the Semantic Web, have been explored in a baseline study. This work examines their application to selected aspects of enhancing digital libraries, such as bibliographic management, bibliometrics, issue tracking, community modelling and visualisation.

Semantic Interoperability

The aim of this task was to develop a common foundation for future semantic interoperability work. Four types of interoperability were recognised: system, syntactic, structural and semantic with the latter being the primary scope of the study. A range of theoretical models, architectural characteristics, semantic services and standards were investigated.

Interoperability of eLearning Applications with Digital Libraries

The task focused on addressing the following questions: (a) What are the major architectural requirements and workflows for effectively supporting eLearning applications running over digital libraries? (b) What are the major interoperability requirements for digital libraries and eLearning systems? (c) What are the management requirements and tools for audiovisual material and 3D object semantic representations, which form the basis of many collections of learning resources? This has been a major area of work with strong links to the audio-visual cluster.

Ontology-driven Interoperability

This activity builds on the foundation work by investigating and developing methods for the integration of heterogeneous data types, models, upper level ontologies and domain specific knowledge organisation systems (KOS). Activities include production of a complete set of models and semantic mappings demonstrating the harmonisation of FRBR-CIDOC-CRM core ontologies, and a series of mappings which show the relationships between the CRM core ontology and the metadata schema of TEI and Dublin Core. The value of semantic mappings is illustrated by a prototype demonstrator in the environmental archaeology domain: to achieve effective search across different databases and associated controlled vocabularies or thesauri, a mapping from domain ontologies (thesauri) to an overarching common schema (the CRM), is required.

Results

Foundational work: digital repositories, knowledge extraction and semantic interoperability.

- A number of substantive reports have been produced: Evaluation study on Digital Repositories which covers scholarly communications, research repositories, e-Learning and multimedia repositories, subject access and semantic interoperability; "The requirements for and usage of extracted knowledge" and "Semantic Interoperability in Digital Library Systems".
- 9th DELOS Thematic Workshop on Digital Repositories: Interoperability and Common Services held in Heraklion, Crete on 11-13 May 2005, with the Preservation cluster and a joint Programme Committee. The keynote was given by Sandy Payette, Co-Director Fedora Project, Cornell University, USA "Rethinking the role of repositories in scholarly communication" with publication of the Proceedings.
- Through the KESI cluster partner University of Southampton, DELOS sponsored the Berlin 3 Open Access conference 28th February- 1st March 2005 : Progress in Implementing the Berlin Declaration on Open Access to Knowledge in the Sciences and Humanities.

Research and development: e-Learning and digital libraries

- This task initially examined metadata standards for Digital Libraries (e.g. METS), eLearning (e.g. SCORM) and audio-visual content descriptions (e.g. MPEG-7), and produced mappings between them. Based on these data, an integration framework and a formal service-oriented architecture (ASIDE - Architecture for Supporting Interoperability between Digital Libraries and ELearning Applications) was developed and validated with a proof-of-concept a demonstrator.
- In addition, further extensions to the GraphOnto tool for metadata management across integrated repositories of various kinds, (audio-visual, 3D graphics etc.), have been developed. Use of this tool will facilitate semantic interoperability within the DelosDLMS.
- Specification and development of the Intelligent 3D Visualisation System (I3DVS) has enabled semantic enrichment of a variety of 3D models and scenes, including crystal molecules and geospatial maps.

Research and development: Ontology-driven interoperability.

- The upper ontologies FRBR and CIDOC-CRM have been harmonised and integrated, in collaboration with the CIDOC CRM-SIG and the IFLA-FRBR Review Group. Integration was based on reformulation of FRBR as an RDF/OWL compatible ontology with complete modelling of performing arts as an exemplar.
- Semantic mappings have been achieved between CIDOC-CRM and MPEG-7 to allow exploitation of cultural heritage documentation with semantic multimedia descriptions. A transformational process has been documented and transformation software is being developed.
- The practical case study demonstrates the value of mapping domain ontologies to common core ontologies, through leverage of the English Heritage (EH) application/extension of the CRM core schema to EH archaeology (CRM-EH). EH have approved the extended model and the EH CRM extension is available as a separate RDFS/OWL file, which can be loaded independently from the CIDOC CRM. It will be available on the CIDOC CRM website.
- The cluster is contributing terminology services to the DelosDLMS. These services allow search functionality to be augmented by KOS-based vocabulary and semantic resources. The service works with thesauri or related Knowledge Organization Systems (KOS) represented in SKOS format. The service has been developed from related research activity, and is based on a subset of the SWAD Europe SKOS API, with extensions for automatic concept expansion. SKOS_WS is a SOAP Web service for vocabularies represented in SKOS Core Vocabulary.

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DELOS Clusters

Preservation

Integrated research in preservation can provide the methodological framework and theory for ensuring that digital libraries research addresses preservation issues and digital libraries incorporate preservation elements in their design. The research agenda in digital preservation is very broad and the research activities are fragmented and in need of integration. This cluster focuses on enhancing preservation methods, tools and functions within the context of digital libraries. It has broad goals to promote the adoption of preservation technologies in digital library development designs, to raise the profile of digital preservation issues within the Digital Library Community, and to increase collaboration with other international researchers conducting research within the digital libraries and preservation communities.

Objectives

The Preservation Cluster has four strategic goals:

- To eliminate the duplication of effort between research activities by creating an integrating framework to co-ordinate and promote research and projects and to enable identification, collection, and sharing of knowledge and expertise,
- To examine core issues that will deliver essential guidelines, methods, and tools to enable the construction of preservation functionality within digital library activities and deliverables are created,
- To establish testbeds and validation metrics. These will provide a framework for testing preservation strategies, for establishing the preservation worthiness of digital library implementations, and create greater w comparability between research and implementation activities,
- To relate the digital preservation research agenda more directly to the development of exploitable product opportunities and to develop links with the industrial sectors.

Activities

The Cluster has focused its activities on five major topics:

- Establish a framework for a digital preservation testbed environment and produce metrics for testing and validating digital preservation strategies,
- Contribute to the development of digital repository frameworks and mechanisms for validating the suitability of digital repository implementations. Evaluate the current and emerging systems and storage models for digital repositories,
- Contribute to the development of file format registries and the mechanisms for their use through the definition of relationship between file format types and preservation methods and to assess the viability of producing generic metrics to measure the viability of this preservation approach,
- Define framework for documenting behaviour and functionality. Develop an overview of the attributes of functionality and behaviour that need to be represented and mechanisms for representing them,
- Develop the requirements for a preservation functionality-modeling tool and integrate that into design and development technologies.

More recently the activities have concentrated on the following:

- integrating the preservation concepts that have been developed by the cluster with the digital library reference model that is being defined by DELOS,
- making progress on the semi-automation of the processes of ingesting material into preservation environments so as to improve construction of digital libraries,
- examining how best to deliver a substantial corpus of documents that will support measurable research in the area of automated metadata extraction,
- completing the delivery of tools to support the application of utility analysis to the selection of preservation approaches,
- examining processes of integrating the preservation tools developed by the cluster to support automatic re-appraisal of holdings.

Results

The most important result of the cluster has been the starting of collaboration among different groups, an initial integration of the research activities across distributed research teams, and the development of a shared problem and research space.
The cluster has also organized a series of Summer Schools on Preservation, which will be continued after the fundinhg period of DELOS on a self-supporting basis, due to the success of the school.

Results have also been achieved in the following areas.

- Digital Preservation Testbed and Evaluation Framework. The DELOS Testbed enforces a deeper understanding of the importance of thorough preservation planning and provides an applicable approach. Its results were picked up by the PLANETS project and will be further developed in its preservation planning work package, focusing on interoperability and integration issues.
- Automated Metadata Extraction. A viable workflow for automated genre classification has been introduced, and progress in summarising existing research on a range extraction has been done, creating the foundation for a well-structured testbed for further research and experimentation.
- Investigation of the Automation of re-Appraisal. The existing appraisal function in the digital archives and libraries has been examined, and the basic rules for retention (or disposal) have been identified. They have been used for an initial definition of a model for the appraisal process (at least for some specific cases).
- Development of an Open Testbed Document Corpus. The preparation of a development plan for an Open Testbed Document Corpus has been one of the core achievements. The implementation of the plan (which requires additional funding) has to be sought in the possible follow on activities of DELOS.

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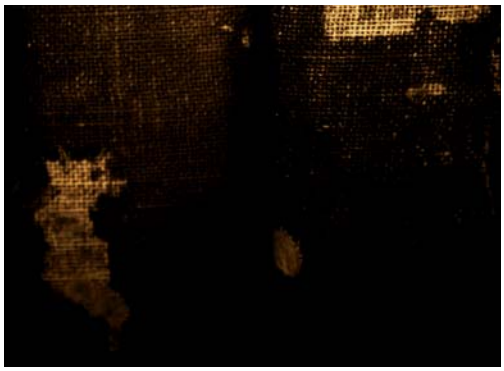

Digital libraries need to be evaluated as systems and as services to determine how useful, usable and economical they are and whether they achieve reasonable cost-benefit ratios. Results of evaluation studies can provide strategic guidance for the design and deployment of future systems, can assist in determining whether digital libraries address the appropriate social, cultural, and economic problems, and whether they are as maintainable as possible. Consistent evaluation methods also will enable comparison between systems and services.

DELOS Clusters

Digital Library Evaluation

Objectives

For supporting the evaluation of digital libraries, the evaluation cluster addressed two main issues:

- Development of evaluation methodologies: A comprehensive theoretical framework for DL evaluation was developed, which served as reference point for evaluation studies in the DL area. Research on new methodologies aimed at overcoming the lack of appropriate evaluation approaches and methods. Finally, the development of corresponding tool kits and test beds enables new evaluations and to ease the application of standard evaluation methods.
- Infrastructure for specific evaluations: Since certain types of evaluations cannot be performed by single research groups, we provided the infrastructure for evaluations that are of great importance for the DL area. More specifically, Delos supported the INEX initiative for the evaluation of XML retrieval and CLEF, the Cross-Language Evaluation Forum.

Activities

The cluster activities with respect to the development of evaluation methodologies and the provision of evaluation infrastructure were organized as follows:

Development of Evaluation methodologies: In the first year of Delos, a workshop on DL evaluation, was organized, which served for collecting existing evaluation approaches and methods. Following, a new evaluation framework was proposed, which served as starting point for further evaluation activities. Based on this framework, a logging standard for interactive DL access was developed, along with tools for visualizing and analysing these logs. In addition, a repository for logging data was set up, which allows for exchange of experimental data between researchers.

Specific Evaluations: In order to apply and test the new evaluation methodologies, some specific evaluations were carried out, like e.g. for TEL, the gateway to the federation of European national libraries.

INEX: (Initiative for the Evaluation of XML Retrieval) is concerned with the evaluation of content-oriented access to structured documents, especially in XML format. XML is increasingly being used in digital libraries and similar systems or platforms. The provision of effective access to XML-based content has become a key research issue, and is the focal point of XML retrieval research. Evaluating how good these systems are, hence, requires test-beds where the evaluation paradigms are provided according to criteria that take into account the imposed structural aspects. INEX addresses these issues since 2002 by organizing annual evaluation campaigns. INEX has a strong international character; In 2007 participants from almost 100 organisations, distributed across Europe, North America, Australia, New Zealand and Asia, participated in the annual INEX run. The aim of the INEX initiative is to establish an infrastructure and to provide means, in the form of a large XML test collection and appropriate scoring methods, for the evaluation of content-oriented XML retrieval systems.

CLEF (Cross-Language Evaluation Forum) promotes research in the field of multilingual system development. Since 2000, CLEF organizes annual evaluation campaigns in which a series of tracks designed to test different aspects of mono- and cross-language information retrieval (IR) are offered. The intention is to encourage experimentation with all kinds of multilingual information access – from the development of systems for monolingual retrieval operating on many languages to the implementation of complete multilingual multimedia search services. This has been achieved by offering an increasingly complex and varied set of evaluation tasks over the years. The aim is not only to meet but also to anticipate the emerging needs of the R&D community and to encourage the development of next generation multilingual IR systems. Like INEX, CLEF has a strong international basis, with over 100 participants from four continents.

Results

The results for the activities described above can be summarized as follows:

- New models and methods for DL evaluation, complemented by a new logging standard for DL access, including a repository for logging data and appropriate analysis software,
- Evaluation results for systems and methods from the specific evaluations as well as from the two large evaluation campaigns,
- XML retrieval test beds for text retrieval (2 corpora: IEEE-CS computer journal articles and Wikipedia) as well as for retrieval form heterogeneous XML collections and for combined text and image retrieval,
- Cross-language retrieval test beds for a variety of cross-language retrieval tasks, such as text retrieval (3 corpora with Web documents, news articles, structured scientific data), question answering, image, spoken document and geographic retrieval.

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The DELOS Reference Model for Digital Libraries

Digital Libraries are increasingly showing the need of a reference model in order to facilitate the definition of systematic approaches to their development, their interoperability and, more in general, their further evolution. Though being a relatively young scientific field, the Digital Library (DL) area is now mature enough to attempt the definition of an overarching framework capable to comprehend all of the different aspects underlying digital libraries.

The members of the DELOS Network of Excellence on Digital Libraries, in collaboration with other international key players in the DL area, have actively worked to introduce a Digital Library Reference Model. This model establishes core concepts and relationships to underpin the field and provide a basis for the development of other foundational elements of the DL universe, like reference and concrete architectures. In particular, it introduces three distinct notions of "systems" (see figure 5):

- **Digital Library** (DL) - a (potentially virtual) organization that comprehensively collects, manages, and preserves for the long term rich digital content and offers to its user communities specialized functionality on that content, of measurable quality, and according to prescribed policies.
- **Digital Library System** (DLS) - a software system that is based on a (potentially distributed) architecture and provides all functionality that is required by a particular Digital Library. When operating in a Digital Library environment, users interact with the corresponding DLS.
- **Digital Library Management System** (DLMS) - a generic software system that incorporates all functionality that is considered foundational for Digital Libraries and provides the appropriate software infrastructure to both produce a basic DLS and integrate additional software offering more refined, specialized, or advanced functionality. An integral part of a DLMS is a "Digital Library Administrative Tool" that is used to choose the appropriate subset of its functionality, e.g., through relevant parameters of its components, and then (potentially automatically, to some degree) install, deploy, and (re)configure a DLS.

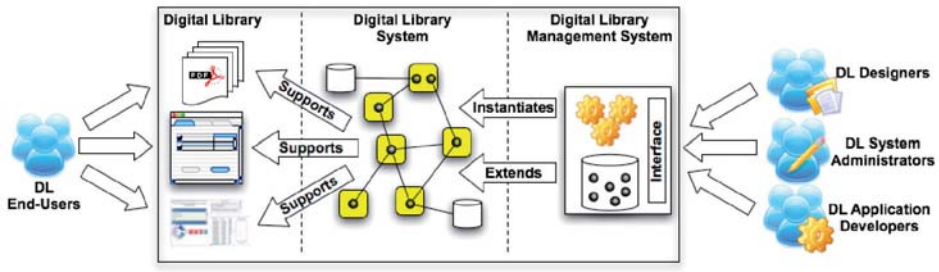

Figure 5. The main Digital Library "systems"

The Reference model defines also the actors interacting with these three systems.

- **DL End-Users:** the actors that exploit the DL functionality for providing, consuming and managing the DL content (they include also the "end user librarian").
- **DL Designers:** the actors that, by exploiting their knowledge of the application semantic domain, define, customize, and maintain the DL system aligned with respect to the information and functional needs of its end-users (this role is sometimes called "digital librarian").
- **DL System Administrators:** the actors that select the software components to install in order to implement the required DL system and decide where to deploy them. They interact with the DLMS by providing architectural configuration parameters, like the selected software components, the hosting nodes, the components allocation, etc (this role is often called "system librarian").
- **DL Application Developers:** the actors that develop the components that compose a DLMS. Dealing with software and application frameworks they realize both the functionality of the DLMS and of the DL system.

Despite the seemingly richness and diversity of existing digital libraries, in reality only a limited range of concepts are defined by all systems as core functionalities. These concepts are identifiable in nearly every DL currently in use. They serve as a starting point for any researcher who wants to study and understand the field, for any system designer and developer intending to construct a DL, and for any content provider seeking to expose its content via digital library technologies. The Reference Model identifies these concepts starting from six core concepts that provide the foundation for DLs: Content, User, Functionality, Quality, Policy, and Architecture (see Figure 6).

These basic concepts are applied separately to the three entities comprising the notion of Digital Library, and they have a nice double inclusion property, as schematically depicted in Figure 7. Moving from the abstract view (the DL) to the concrete view (the DLMS), only the new additional refined concepts and their relationships need to be added, and the same is true also when moving from the most simple view (the one of the End User) to the most complex view (the one of the DL Application Developer).

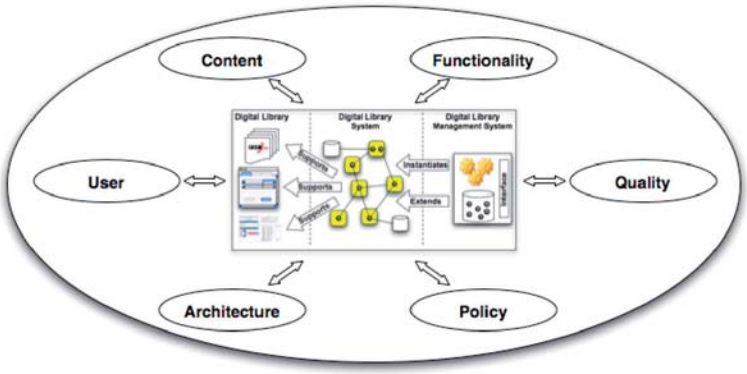

Figure 6. The Digital Library Universe: Main Concepts

The relationships and characteristics of all the different concepts needed to completely describe a DL are represented in the model through the use of Concept Maps, a simple representation of the conceptual model based on the well known usage of graphs whose nodes are concepts and arcs represent their relationships. Figure 8 shows the map that specifies the relationships among the six top level concepts and the three systems of DL universe. In the model, each concept in turn is expanded in more detailed components and their relationships are defined. In the present version the model comprises the definition of 189 different concepts and 36 main relationships.

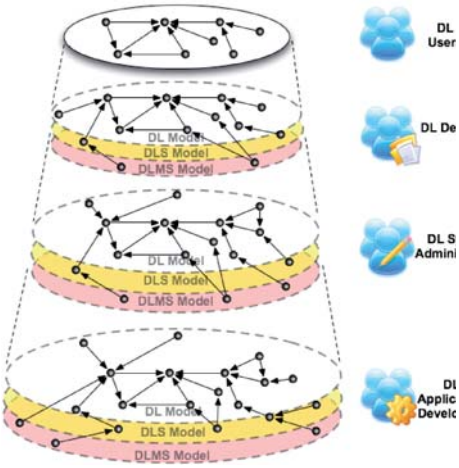

Figure 7. Inclusiveness of concepts through systems and actors

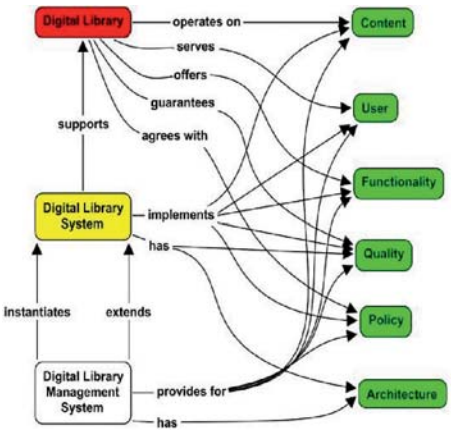

Figure 8. The higher level concepts and relationships

For more Information on the DELOS reference model:
http://www.delos.info/ReferenceModel

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DELOS DLMS

Infrastructure and Services for Future Digital Library Systems

DelosDLMS is the globally integrated prototype and demonstrator for future digital libraries, a key result of the DELOS Network of Excellence. DelosDLMS offers various services and specialized DL functionalities provided by DELOS partners on top of a reliable and scalable middleware infrastructure. Currently, it combines text and audio-visual searching, offers new information visualization and relevance feedback tools, provides novel interfaces, allows retrieved information to be annotated and processed, integrates and processes sensor data streams, and finally, from a systems engineering point of view, can be easily configured and adapted. DelosDLMS provides functionality in a single system that is not available in any known system so far.

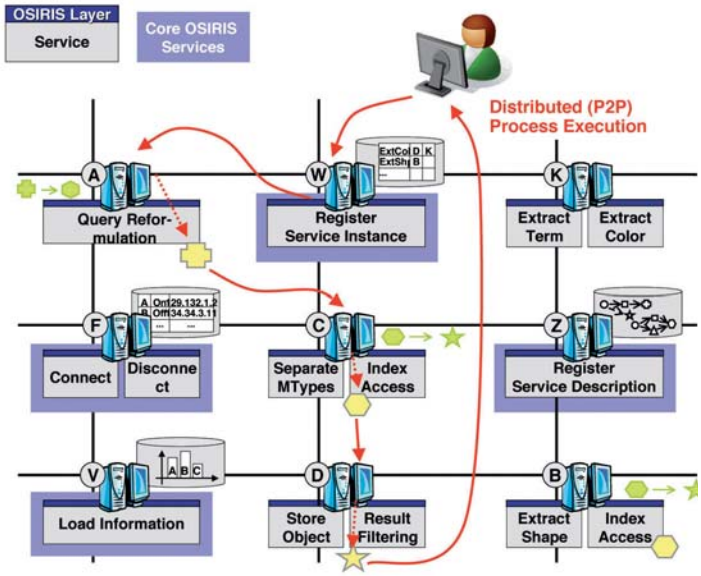
The main contributions to DelosDLMS are

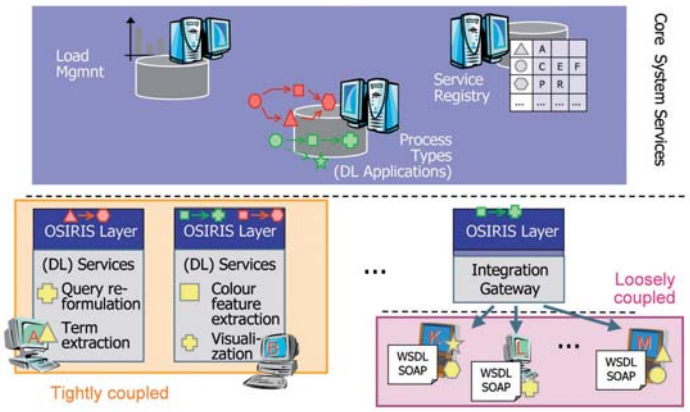
- Middleware, Search Infrastructure and Image Similarity (OSIRIS/ISIS) from ETH Zurich and University of Basel
- Self-Organising Map Visualization (SOM) from University of Konstanz
- 3D Feature Extraction and Object Retrieval from University of Florence
- Audio Retrieval from University of Vienna
- Interactive Paper (iPaper) from ETH Zurich
- Daffodil as alternate interface from University of Duisburg-Essen
- Annotation Service (FAST) from University of Padua
- MedioVis Interface from University of Konstanz with Visualisation Services (DARE) from University Roma "La Sapienza" and Personalisation Services from University of Athens
- Video Feature Extraction, Annotation and Video Retrieval (Soccer) from University of Florence and partners
- Natural Language and Speech Interface, Semantic Video Services (COCOMA from Technical University of Crete and partners)
- Query Expansion (FACET) from University of Glamorgan
- Minerva P2P Search Engine from MPI Saarbrücken

The Infrastructure

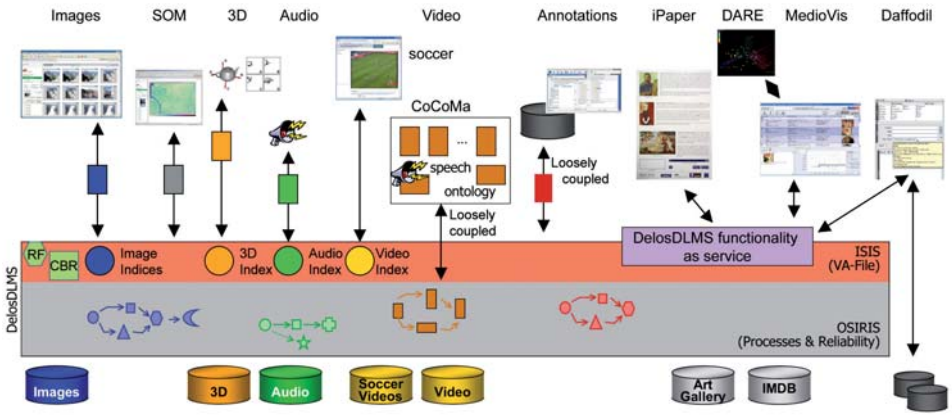
DelosDLMS is based on the OSIRIS middleware from ETH and Basel and extends the indexing and search services (ISIS) by many DL services form DELOS partners. OSIRIS addresses interoperability at service level by supporting the combination of services into processes. OSIRIS consists of application independent services, e.g. for registering service types.

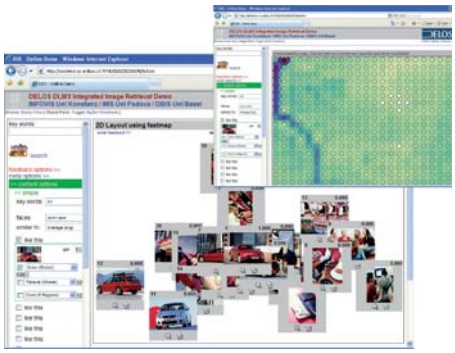
The OSIRIS layer takes care of a fully distributed (peer-to-peer) execution of processes.
It encompasses Grid-like system functionality such as dynamic deployment of service instances and load balancing.





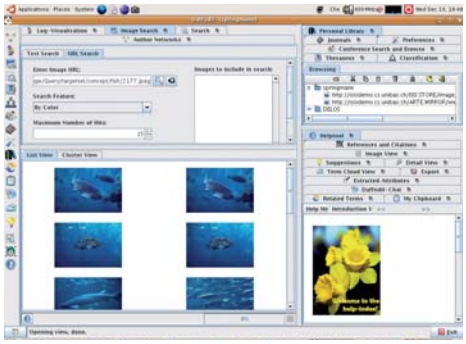
Combined text/content retrieval with relevance feedback and visualization, P2P search





DelosDLMS offers combined predicate, text and content-based image retrieval with a 2D visualization of the query result.
It also offers combined text and audio retrieval using the award-winning Vienna audio features.
It supports content-based retrieval of 3D objects from Florence.
In order to explore a collection with regards to a particular feature type, a Self-Organizing Map visualization of a collection from Konstanz has been integrated.
For efficient combined text and content-based searches in very large P2P environments, features from the MINERVA P2P textual search engine of MPI Saarbrucken have been integrated.

Interfaces

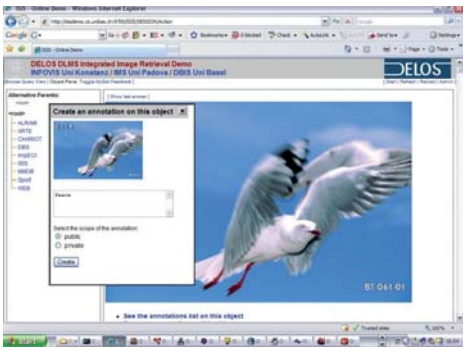


In DelosDLMs the OSIRIS/ISIS Middleware and Image Search functionality is combined with the Daffodil Interface from Duisburg-Essen offering interface functions like visual clustering.

For metadata browsing and interactive processing the MedioVis Interface from Konstanz enriched with visualization (DARE) from Roma "La Sapienza" has been integrated into DelosDLMS in order to give users the flexibility to choose among various tools for intelligent browsing and explorative search. Personalization services from Athens are being added.

For applications in Museums or City Guides, the iPaper interface of ETH Zurich has been added to DelosDLMS allowing users to point to an object on paper or to write a search term in order to receive related information from the Digital Library collection.

Annotations



Objects can be annotated by making use of the FAST annotation service from Padua which has been added to DelosDLMS

Video Services

Special video services from University of Florence allow extracting semantic information from scenes (e.g., in a collection of soccer videos whether a scene is a shot on goal, midfield action, etc.)

Speech, Natural Language Access, and Ontologies

Users can also interact with DelosDLMS using natural language, thanks to the COCOMA speech analysis services developed by the Technical University of Crete. These services exploit an ontology describing a domain to identify additional keywords for suitable queries.

Ontology-based query expansion is supported by the FACET terminology service from University of Glamorgan.

The Contributors to DelosDLMS

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For more Information on DELOS visit
http://www.delos.info
and on DelosDLMS look into
http://dbis.cs.unibas.ch/delos_website/index.html

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Spreading Excellence

Dissemination and Communication

In parallel with the efforts for buiding and integrating a European community for research in Digital Libraries, DELOS has also spent considerable efforts in dissemination and education activities. They have been directed on one side towards the scientific community, to facilitate the integration of the many different technologies underlying digital libraries, and on the other side towards the content owners (libraries, archives, museums, etc) and the interested application communities in order to raise the awareness of the improved functionality and services that digital libraries could bring in a near future.

Publications

Publications in scientific journals and presentations at scientific events are the natural outcome of research activities. The tables in figure 9 summarize the publication activity of the DELOS community members during the first three years of DELOS (at time of printing, final figures for 2007 pubications are not yet available). Table 2 and 3 show the positive influence of DELOS in increasing the number of joint publications.

The DELOS Digital Library

Most of the documents and publications that are in some way related to the DELOS activites, for a total of about 1300 documents (mostly scientific papers, including all papers accepted at the ECDL series of conferences, but also DELOS deliverables, reports, presentations, management reports, etc.) have been gathered in the DELOS Digital Library. The Library is accessible to eveybody through the DELOS web site, but the full text of some documents (e.g. papers presented at ECDL conferences) is available only to members of the DELOS Community.

Scientific Events

Organization and participation in scientific events is also another natural outcome of the research activities. DELOS has organized a number of Thematic Workshops, providing the opportunity to the researchers in the Digital Library field to present results of on-going research activities on specific topics, and to exchange opinions and experiences in an informal and friendly environment.

DELOS has also organized two Brainstorming Workshops, bringing together top researchers from all parts of the world, to focus on specific technology issues and to produce reports on future research direction in the field of Digital Libraries.

Finally, in the frame of the activities of the research clusters, a number of DELOS Workshops has been organized, bringing together members of the DELOS Community. During the four years of DELOS, a total of 36 events have been organised for an estimated total attendance of 3300 person-days.

Thematic Workshops

- Digital Library Architectures , Cagliari, Italy, June 24-25, 2004
- Future Digital Library Management Systems: System Architecture and Information Access, Schloss Dagsthul, Germany, March 29 - April 1, 2005
- Audio-Visual Content and Information Visualization in Digital Libraries, Cortona, Italy, May 4-6, 2005
- Digital Repositories: Interoperability and Common Services, Heraklion, Greece, May 11-13, 2005
- Personalized Access Profile Management and Context Awareness in Digital Libraries, Corfu, Greece, June 29-30, 2007
- Visual and Multimedia Digital Libraries, Modena, Italy, September 14, 2007

Brainstorming Workshops

- Future Research Directions for Digital Libraries, Corvara, Italy, July 8-10, 2004
- Recommendations for the European Union on-line consultation on the i2010 Digital Libraries Program, Juan-les-Pins, France, December 5-6, 2005

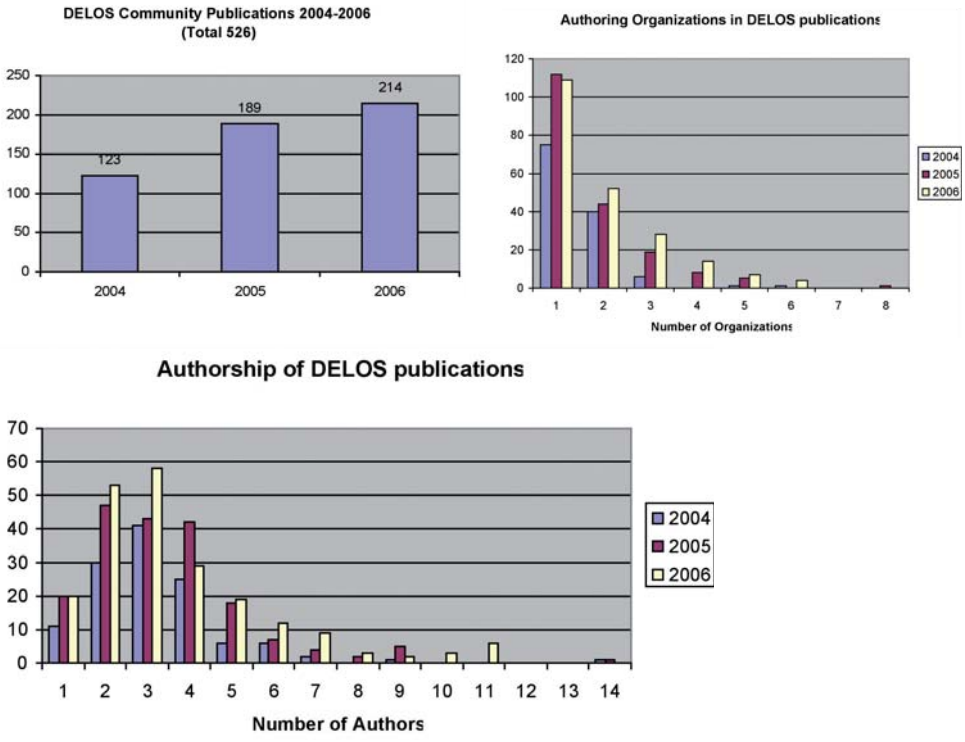


Figure 9. Publications

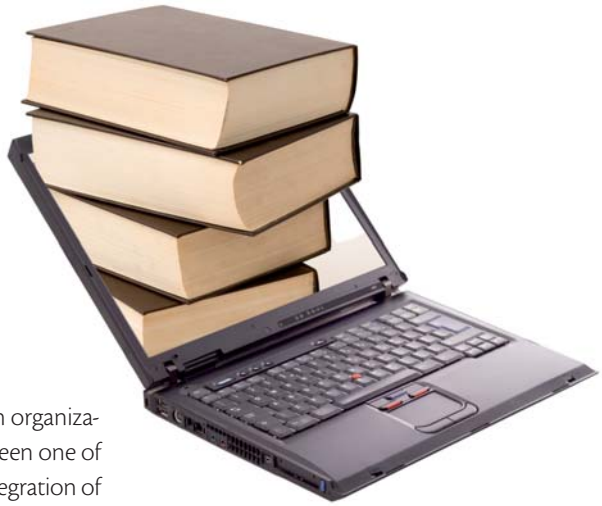
Spreading Excellence

Education and Awareness Raising

Summer Schools

DELOS has organized a series of Summer Schools to provide high-level courses on the domain of Digital Libraries and its underlying technologies. The schools have been directed mostly to members of the research community (in the wide sense), but also to user communities and professionals involved in the design and use of Digital Libraries. Each one-week intensive course consist of nine or ten half-day sessions, having as lecturers distinguished scientists invited from all part of the world. Discussions in smaller groups on specific topics of common interest, with the participation of the lecturers have always been encouraged. The following summer schools were organised during the life time of the Network, delivered by 51 invited lecturers, with a total attendance of about 280 students.

- User-Centred Design of Digital Libraries and Digital Library Technologies, Pisa, Italy, September 6-10, 2004
- Preservation in Digital Libraries, Sophia-Antipolis, France, June 5-11, 2005
- Preservation in Digital Libraries, San Miniato, Italy, June 4-10, 2006
- Multimedia digital libraries: Machine learning and Cross-modal Technologies for access and retrieval (jointly with MUSCLE), San Vincenzo, Italy, June 12-17, 2006
- Digital Libraries for the Digital Librarian: Making the Journey from Traditional to Digital Libraries (jointly with NSDL), Firenze, Italy, May 28-June1, 2007
- Preservation in Digital Libraries, Pisa, Italy, June 3-9, 2007



Joint Workshops and Presentations

DELOS has organized a number of events in collaboration with user communities to raise the awareness of Digital Libraries technologies and to promote technology transfer from research to application domains. Worth mentioning is the cooperation with TEL (The European Library), which has led to the definition of four new DELOS Tasks on the following topics, of high interest to TEL.

- Validation and refinement of the reference model
- Multi-Lingual Information Access
- Personalization capabilities
- User interface design, navigation and visualization services.

Strong cooperation links have also been established with ELAG (Euroepan Library Automation Group) through participation to the ELAG annual conferences with a presentation of the Reference Model and the organization of two workshops, one to present and discuss the DELOS Digital Library Management System, and one to collect requirements (solicited by the European Union) for the future European Digital Library.

DELOS also has participated to a number of events organized by relevant Digital Library stakeholders (Libraries, Museums and Archives) to present the results of the DELOS research activities and to seek opportunities for cooperation. In conclusion, during the four years of activity, DELOS has organized or has actively participated to about 65 events, with an estimated attendance of 4700 person-days.

Research Exchange Program

The exchange of researchers between organizations working on joint projects has been one of the most effective ways to achieve integration of the working teams and exchange of skills and results. For "exchange of researcher" is meant the visit of a researcher from one research organization (not necessarily a DELOS member) to a DELOS member, for a period of a few weeks, to carry on joint research on a specific topic of common interest. DELOS has supported these exchanges by providing funding to cover the additional expenses incurred in the exchange. A total of 27 exchanges have been funded in the four year period.

DELOS Award

DELOS has established an award (in the amount of four thousand euro), named "DELOS Research Exchange Award", to be given each year to the best paper authored and presented by a young researcher at the ECDL Conference. The award recognizes the achievement of the young researcher by offering the author a chance to spend a period of time (at least one month) at a DELOS European partner research organisation.

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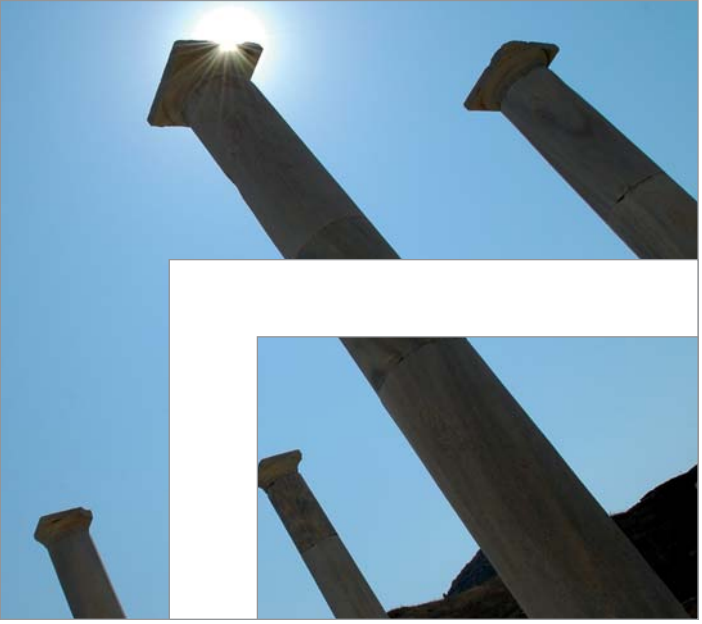
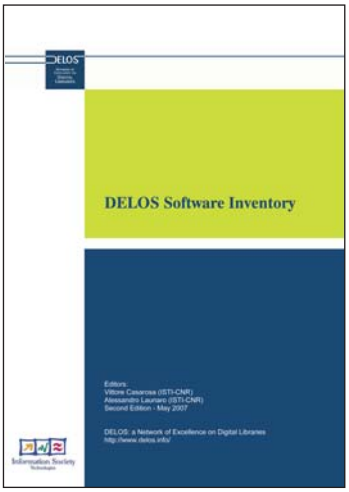


Spreading Excellence

DELOS Software Inventory

In the perspective of the DELOS mission as a Network of Excellence, the main outcomes of its activities are knowledge and prototypes. As a matter of fact, many of the DELOS research activities lend themselves to the implementation of software prototypes, which are useful to validate research hypothesis and/or to evaluate the applicability of research results to practical applications. DELOS has developed a catalogue of software prototypes and packages developed by partners of the DELOS Community (not necessarily during the activities related to DELOS tasks) that are demonstrators or prototypes of technologies relevant to Digital Libraries, and that might be of interest to some user communities. The catalogue (the DELOS Software Inventory) is available both on the web site and as a DELOS publication. It contains a brief technical description of the prototypes, an indication of their possible application fields and the contact points for users interested to test the packages. The Inventory is one of the vehicles for exploring potential cooperation and technology transfer to interested user communities and to verify the possible interest of commercial partners.



DELOS Software Components:

3D CBR	Three Dimensional Content Based Retrieval
CBIR	Content Based Image Retrieval
DelosDLMS	Digital Library Management System
eaSIM	Java simulation and development environment
getRole	Role Mining with Cluster Analysis
iGesture	Gesture Recognition Framework
IEMSR	Metadata Schema Registry
ISIS	Interactive Similarity Search
ITR	Item Recommender
MESSIF	Metric Similarity Search Implementation Framework
MILOS	Multimedia Content Management System
MINERVA	Peer-To-Peer Web Search Engine BINGO! - Focused Crawler
MM4U	A Component Framework for Personalized Multimedia Applications
O'GRAPE	OSIRIS Graphical Process Editor
OSIRIS	Open Services Infrastructure for Reliable and Integrated Process Support
OSIRIS-SE	OSIRIS Stream-Enabled
P2P DL	Peer-To-Peer Digital Library
RPextract	Music Feature Extractor
Sightseeing4U	Development of Personalized Mobile Multimedia Applications
SOMToolbox	Implementation of Self-Organizing Map Models
Transformation4U	Transformation of Multimedia Documents for Mobile Applications
VBI-ERAT-LVPA	Integration of Complementary Archaeological Sources
xSMART	Semi-Automatic Context-Aware Authoring Tool

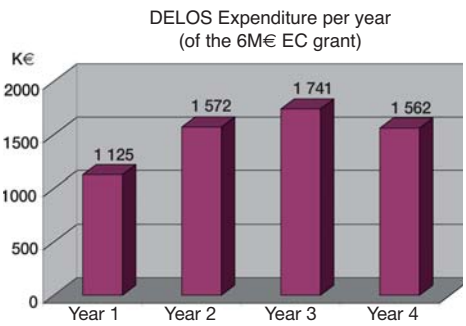
For details of the DELOS Software Inventory (contact, description, usage, prerequisites, legal), please consult: http://www.delos.info/Inventory

Finances

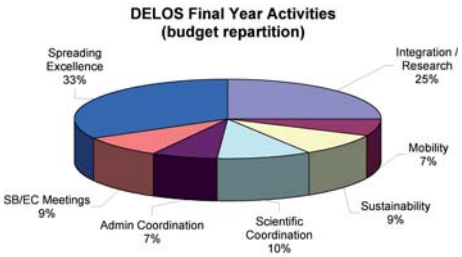
After four years of activity, the DELOS partners have jointly and successfully contributed to the delivery of their global work programme objectives. Activity has ramped up over the Network lifetime and the funding from the European Commission has been transformed into quality output to the benefit of the Digital Libraries scientific and user communities.

The European Commission grant of 6 Million Euros represents 38% of the total investment that the DELOS partners contributed to the Network of Excellence during its four years of activity.

While research activities have been ramping up over the first three years, the Scientific Board has decided to focus the last period on finalising the on-going research work and on disseminating the outcome of the project through a series of events including conferences, workshops and summer schools.



As well as research and dissemination, DELOS financed inter-cluster integration work, in particular through the Research Exchange Programme that allowed scientists to carry out collaborative work at remote partner's sites. 30 such exchanges took place over four years, for an aggregated duration of 60 weeks.



In the final stage of the Network, special effort has been placed on publishing DELOS scientific results and on taking the specific actions needed to carry the network forward beyond the end of the EC contract.

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Achievements and Perspectives

DELOS Digital Library Reference Model

The term Digital Libraries corresponds to a very complex notion with several diverse aspects and cannot be captured by a simple definition. A comprehensive representation of Digital Libraries, encapsulating all potential perspectives, is required. This has led DELOS to start an effort, whose aim is to set the foundations and identify the cornerstone concepts within the universe of Digital Libraries, facilitating the integration of research and proposing better ways of developing appropriate systems. Begun by a core group of DELOS members, the reference model activity now involves other DELOS and non-DELOS researchers, working from the perspectives of different domains. Liaisons with similar activities carried out by other international initiatives have been established in order to achieve a global and stable level of consensus on the model.
Several documents have been produced, by exploiting the experience that DELOS research groups and other worldwide groups have acquired over the years on the functionality and architecture of operational digital library systems.

- User Requirements vs. Provided Functionality in Current Digital Library Systems (a DELOS deliverable) is an analysis of existing digital library systems that has proven useful to sketch an initial broad overview of the concepts of digital library systems at the base of the reference model;
- the Digital Library Manifesto (initial draft) has set the foundations and identified the cornerstone concepts within the universe of Digital Libraries;
- the Digital Library Reference Model (initial draft, a DELOS deliverable) is a conceptual framework representing the characteristics of the main "systems" of the digital library universe. This model details the concepts related to the six main cornerstones of DL "systems", i.e., content, user, functionality, quality, policy, and architecture, and it specifies the mutual relationships between these concepts and the constraints that hold among them.
- the Digital Library Reference Model (Version 1) comprises three parts: the Digital Library Manifesto (Version 1) is the final version of the Manifesto; the Digital Library Reference Model in a nutshell is a condensed summary of the essential concepts defined in the model; the Reference Model is the complete full description of all the concepts defined in the model (189 different concepts) and the relationships that hold among them (36 different relationships).

As in any other scientific and technical field, Digital Library technologies and applications keep evolving, and therefore this first version of the DELOS Reference Model has to be considered not just as the arrival point, but as the first milestone of a continuous effort.

DELOS Digital Library Management System

A central task in DELOS is to jointly build a prototype for the future Digital Library Management System that makes available the results of many groups in DELOS. The prototype is based on the OSIRIS / ISIS middleware that was started at ETH and further developed at UMIT, at the University of Basel and at the University of Konstanz.
By integrating the contributions of several DELOS partners, the system combines text and audio-visual searching, offers personalized browsing using new information visualization and relevance feedback tools, allows retrieved information to be annotated and processed, integrates and processes sensor data streams, and finally, from a systems engineering point of view, is easily configured and adapted while being reliable and scalable.

DELOS Perspectives

In the final year, the European Commission has asked the consortium to produce a Marketing and Business Plan that will give directions as to the best way to continue the DELOS effort beyond the scope of the funded network.
It is anticipated that the DELOS partners will propose joint projects in the 7th European Framework Programme, building on the results they have achieved while being active members of the DELOS Network of Excellence.

In order to continue and to extend this fruitful collaboration beyond the EC funding period, the DELOS Association is being established to carry forward the DELOS spirit into the future.

This non-profit association will register its statutes and become a legal entity in December 2007. Initially animated by the Scientific Board and composed of DELOS partners, it will elect its president and governance bodies in January 2008. The association will be opened to individual and to institutional members, who will generate the larger part of the entity's revenue stream. Complemented by a small margin from the organisation of dissemination events (workshops, tutorials, summer schools, conferences), the DELOS association will cover its operating expenses and will be able to maintain its core activities :

- the DELOS website,
- the DELOS publishing activities,
- a series of DELOS labelled scientific events,
- a consulting offer towards interested business partners, mostly based on the DELOS Software Inventory,
- its networking activities, keeping the DELOS members connected and extending the European Digital Library community.

Detailed information on the DELOS Association will soon be available on the DELOS website.

Appendix I

DELOS Network of Excellence

Final Report of the Advisory Board

January 2008

Introduction

The Advisory Board (AB) of the DELOS Network of Excellence (NoE) met with the Scientific Board (consisting of cluster leaders of the NoE) on Friday, December 6 2007 at the Grand Hotel Continental, Tirrenia Italy. The report below summarizes the proceedings of the meeting and offers a final evaluation as well as recommrndations for the network.

The main objective of the DELOS NoE is to define and conduct a joint program of activities in order to integrate and coordinate on-going research of major European research teams in the field of digital libraries, In order to develop next generation digital library technologies. This means that DELOS has -- in addition to traditional NoE activities such as workshops, summer schools, working groups, etc. -- the task of carrying out a collaborative research program. In its last year, DELOS has 46 members, organized into clusters.

The mandate of the AB is to perform an annual general assessment of the progress of the Network and then provide recommendations on how to improve efficiency and excellence.

The composition of the AB has as follows:

- Edward A. Fox (Chairman, IEEE-CS Technical Committee on Digital Libraries; Director of DLRL – Digital Library Research Laboratory, Virginia Tech; Professor, Department of Computer Science, Virginia Tech, USA)
- Stephen Griffin (Program Director, Digital Library activities, NSF Computer and Information Sciences and Engineering Directorate, Arlington, USA)
- John Mylopoulos (Fellow, Royal Society of Canada – Academy of Sciences; Professor, Department of Computer Science, University of Toronto, Canada; Distinguished Professor, Department of Information Science and Engineering, University of Trento, Italy)
- Keith Van Rijsbergen (ACM Fellow; Professor and leader of the Information Retrieval Group, Department of Computing Science, University of Glasgow, UK)

Keith could not attend the meeting.

The Meeting

14:30-15:00 Introduction and general overview -- Costantino Thanos and Yannis Ioannidis

Costantino opens the meeting. Notes the role of DELOS in creating an active European research community. First year focused on creating a community, during the second year the scientific board was set up and a research programme was launched.

Year 3 focused on the definition of a reference model and integration activities around the concept of DelosDLMS. Year four focused on two evaluations, one internal the other by the AB.

Among many dissemination events, there have been two DELOS conferences (with 120 and 100 participants respectively) and many other research meetings.

Yannis summarizes research achievements, for the lifetime and 4th year of the network. There is no follow-up to DELOS. However, there have been many spin-off European projects.

The reference model developed by the DELOS community is in very good shape. There have been applications thereof to eHealth, eCulture, and eLearning.

Research within the network was organized into 25 tasks. The integration task force came up with the DelosDLMS and proposed a digital library reference model. The model addresses content, user, functionality, quality, policy all integrated through an architecture.

Digital Libraries remains a rich and open research area. In particular, issues concerning socialization and covering collaboration, personalization; interoperability, and multi-linguality have not been adequately addressed.

In summary, there is a strong sense of continuity within the DELOS community. The DELOS association is one way to keep DELOS members in touch.

15:00-16:30 Summary of DELOS activities over the 4 years -- Cluster coordinators

Hans Schek covers the DL architecture (WP1) and presents results for each task. A demo earlier in the day illustrated graphically the results of this work package.

Yannis Ioannidis goes next on querying and personalization (WP2). This cluster's work is founded on the notions of proximity, peer, and profile. As part of its work, this cluster organized 5 thematic workshops, the last one on personalization and context in DLs.

Stavros Christodoulakis talks about retrieval and annotation, focusing on semantic aspects (WP3). Retrieval is similarity-based, and includes retrieval of images and 3D objects. For the latter, they have experimented with view-based, statistical and structure-based techniques.

Tiziana Catarci presents the user interfaces and visualization work package (WP4). The focus here is on user-orientation. The cluster includes a large number of partners. Among other topics, research here has addressed relevance feedback and visualization for mobile users (also a WP3 task).

WP5 has focused on interoperability between DLs and eLearning environments. The report was also presented by Stavros (Liz Lyon is in charge). Work here focused on harmonizing CIDOC with FRBR. They also worked on interoperability between OWL and XML schemas.

Seamus Ross reports next for the preservation cluster, WP6. The aim here is to consider how preservation can be made an integral part of a DL framework.

Norbert Fuhr presents the evaluation work package, WP7. Two evaluation initiatives were developed. INEX focuses on structured documents. Many external organizations ended up participating in this WP. CLEF focuses on cross-language evaluation. This initiative has engaged an even larger community.

The report on the dissemination work package (WP8) is given by Vittore Casarosa. There has been a broad spectrum of dissemination activities, undertaken by DELOS clusters and the whole DELOS NoE.

18:00-18:30 DELOS Finances -- Philippe Rohou

Philippe reports last on DELOS finances. It will take a few months to close down all accounts and report on all activities. Research activities for the network ended in June 2007, rest of the year has focused on dissemination activities. The whole budget of DELOS was about €6M over 4 years. About €1.2M was used for research each year.

18:30-19:00 AB members meet and produce a preliminary assessment. This is presented to the Scientific Board.

The Assessment

The AB assessment can be summarized in terms of five Ws:

1. Wonderful
2. What potential benefits
3. Without
4. Will
5. Wrap-up

Wonderful

In short, this NoE has delivered great science by a distinguished collection of accomplished as well as up-and-coming researchers. Their accomplishments are many and notable, including a large harvest of publications in top-rated venues, a large number of well-trained young researchers, and an impressive list of follow-up projects.

Points in support of this assessment:

- Broad range of research covered, from theory to architecture to systems to interfaces, e.g., from the reference model to the DLMS;
- Dignity, integrity, hard work, dedication – achieving what was planned, what developed as a discipline-wide vision, and what emerged as ambitious goals;
- Real collaboration and integration at all levels by an interdisciplinary and multinational team with intensive cross-fertilization across perspectives and approaches;
- Leveraging a small investment by the EU to connect top-notch individuals and projects to achieve large-scale solutions and global visibility;
- Adapting to guidance of the EC and the advisory and scientific boards to move in new and important directions, such as helping address the needs for a multilingual Europe, as well as the new agenda of moving to the European Library, and further towards the European Digital Library.

As we said in our last Advisory Board report, we believe that DELOS has been incredibly successful. It has continued the steady progress that has been evident during each of the last years; if anything, progress has accelerated this year. We believe that the work has been in the right direction; for example the plans for 2007, and suggestions we made to improve those plans, have been properly heeded.

What potential benefits

DELOS has made important contributions in the DL research and development arena that should have broad impact. Information is ubiquitous, so the scope of DELOS goes well beyond libraries, even beyond museums and archives. Indeed, there are fundamental contributions across many aspects of Information Systems; these are at the heart of the on-going Information Revolution and the forthcoming Information Age.

Thus, parts of the DELOS effort already have been applied to areas related to healthcare. There has been considerable attention to culture, history, and preservation of digital versions of literary, linguistic, and artistic creations as well as natural and man-made artifacts.

More broadly, DELOS has played a key role in helping move not only into the Information Age but also toward the emerging Knowledge Society.

As an aside, but providing added evidence of the importance of that work, it should be noted that the National Science Foundation in the USA has a variety of related initiatives. Since there has been a decrease, especially in places like the USA and parts of Europe, in the number of college students selecting careers in computing, it is important to demonstrate the applicability of computing efforts, such as digital library R&D. Transforming computing education, making clear its applicability, is a key part of the NSF CPATH program (see http://www.nsf.gov/cise/funding/cpath_faq.jsp). One example CPATH effort is the Living In the KnowlEdge Society (LIKES, see http://likes.dlib.vt.edu/) initiative, led by Virginia Tech, to ensure that college graduates with interest are able to function effectively in the emerging Knowledge Society.

Without

Without further support, the wonderful accomplishments of DELOS might not lead to all the benefits possible, and Europe might needlessly suffer. The current situation with commercially available tools and systems is such that the vision of the European Digital Library might not be realized. Existing solutions, like those from Google, are not tackling key problems that are particularly challenging in the European context. Thus there would be little real support for the rich linguistic diversity of Europe, with search engines underlying US-based systems from Google, Microsoft, and Yahoo not covering key language content, and not supporting cross-language searching. The CLEF and TrebleCLEF efforts are among the best in the world, and should be encouraged and extended and applied to these key challenges and opportunities that are most visible in Europe.

Without the advanced information system approaches that have come from the DELOS arena, connecting across media types, addressing a variety of users and user needs, and working toward solutions in keeping with the emerging Semantic Web (and from the WWW to Web 2.0 to Web 3.0), there will be little interoperability. Solutions will work, as they do now with Google, but only at the low end, as a type of least common denominator set of capabilities. Because Europe has such diversity, which is a key asset that enriches the cultural life of the Community, and which could lead to enrichment in scientific, scholarly, and economic domains, a more focused and intelligent approach is needed. Using domain specific solutions gives better results, but calls for deeper analysis and understanding, and long-term investment in research as well as development and deployment.

Will

Research has long-term payoffs that can be enormous. In the increasingly competitive global society, innovation and keen insight often leads to dramatic economic and social advancement. Looking ahead, holding the line, supporting “big science”, has always led to dramatic improvements.

It is important to remember that computing and IT are at the heart of the modern economy as well as the life of the future. Globalization and open communication will move forward, but those who lead will benefit the most commercially, and leadership depends on computing and IT.

In physics and healthcare, it is clear that powerful computers, fast communications, and handling of massive amounts of data are needed. Grid computing means that distributed information systems can be constructed and deployed in flexible ways. With interoperable software, this really means big science. DL now is a big science area, where continued investment is required for the long term. DELOS has demonstrated this more than anywhere in the world, and has the lead, which can be extended to other areas of information systems too.

Wrap-up

There are some activities that DELOS could undertake, with minimal effort, to increase the impact of its efforts. In our last report we asked a set of questions, and outlined a number of scenarios. Here we add some specific suggestions.

First, there could be some enhancement and testing and refinement of the WWW site. It is important that the tasks undertaken by the typical users of the site be well supported; this can be verified through usability engineering. Some small changes and additions would ensure very broad impact.

Second, the various parts of the results of DELOS could be highlighted through tailored views or value-added services targeting particular segments of the user base. Thus, the WWW site could support: graduate students, researchers, educators, entrepreneurs, and the general public. For example, to fully engage and support graduate students, those who have helped with DELOS activities could be highlighted by being listed and by having their publications identified. In particular, every masters or doctoral thesis at all related to DELOS could be made accessible through the WWW site through targeted browsing and search. Also, the collection of electronic

theses and dissertations (ETDs) could be made available worldwide through collaboration with the Networked Digital Library of Theses and Dissertations (NDLTD; see www.ndltd.org) if an OAI data provider for the ETD metadata were supported by DELOS or one of its supporters. Likewise, the software inventory could be organized, highlighted, and advertised. Since people from various other disciplines would benefit, having several sets of categories and tags should be attached to aid searching and browsing.

Third, more publicity is needed about DELOS accomplishments. There should be some submissions to D-Lib Magazine (www.dlib.org), JCDL 2008 (http://www.jcdl2008.org/), and other venues. There could be more DELOS research results published in journals (e.g., IJDL, see http://www.springer.com/computer/database+management+&+information+retrieval/journal/799). A book or two could be written; one possibility is a textbook for DL courses, which also could serve as an historical record and a reference work.

Fourth, the successful summer school efforts should be extended into even broader connection with DL education activities in Europe and beyond. Anyone in a library or information science program in Europe should learn about DELOS efforts. Many of those in computer science or similar fields (e.g., business information technology) would benefit from access to particular subsets of DELOS deliverables.

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