Libraries have always been a valuable source of knowledge. The technology evolution transformed the traditional libraries into digital ones which arose the need of efficient serve of the huge amount of information that now exists in the form of digitized content. The focus of this book is on the search of innovations especially in areas and subareas relevant to digital library data management and processing—innovative and creative tools for approaching cultural assets, applications and services for better access and exploiting of the rich and diverse digital cultural heritage in a sustainable way, intelligent curation, creative use/re-use and remix, reinterpretation, study, understanding, analysis, personalization, adaptation, semantics, etc. The research deals with important issues of handling data directly, affecting the economy (as presented by creative and re-creative industry), the public sector (cultural institutions—museums, libraries, galleries, etc.), education, and society as a whole.

For the last ten years the research team of D. Paneva-Marinova, M. Goynov, and D. Luchev has been working in the field of digital culture (DC) and its online presentation, accessibility, exploitation, and reuse through new tools and services to model, analyze and visualize vast amounts of DC data, saved in digital libraries and repositories.

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Desislava Paneva-Marinova, Maxim Goynov, Detelin Luchev

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Constructive Block in Ecosystems for Digital Cultural Assets.

Basic Functionality and Services

The monographic study *Multimedia Digital Library: Constructive Block in Ecosystems for Digital Cultural Assets. Basic Functionality and Services* is developed by a team from the Institute of Mathematics and Informatics, Bulgarian Academy of Sciences under several national and international research projects.

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Reviewers: Prof. Radoslav Pavlov, Ph. D. (Institute of Mathematics and Informatics, Bulgarian Academy of Sciences), Prof. Krassen Stefanov, Ph. D. (Faculty of Mathematics and Informatics, University of Sofia “St. Kliment Ohridski”)

Preface

Preserving the cultural, historical and scientific heritage of various world nations, and their thorough presentation is a long-term commitment of scholars and researchers working in many areas. From centuries, every generation is aimed at keeping record about its labour, so that it could be revised and studied by the next generations. New information and multimedia technologies have been developed during the past couple of years, which introduced new methods of preservation, maintenance and distribution of the huge amounts of collected material. There are various conceptual and technically feasible solutions available, such as digitalization of cultural and historical artefacts and creation of multimedia information archives, web presentations of valuable artefacts in virtual museums, galleries and digital libraries, 3D virtual realities, which present places of culture and history, digital modelling and simulation, aiding the conservation, restoration, storing and showing artefacts, *etc*.

This analytical survey is developed by a team from the Institute of Mathematics and Informatics, Bulgarian Academy of Sciences (IMI—BAS) and presents its scientific research and developments at the innovation ecosystems of digital cultural assets, digital library management systems, tools and services. It is a result of several national and international projects in the field, as follows:

- Research project “Concepts and Models for Innovation Ecosystems of Digital Cultural Assets” (Contract № DN02/06/15.12.2016 between IMI—BAS and the National Science Fund of Bulgaria (2016–2018);
- Research project “Digital cultural heritage “North+”: documenting, preserving and providing access to the cultural heritage in libraries, museums, archives and galleries in North and Central Bulgaria”, awarded by grant within Programme BG08 ”Cultural heritage and contemporary arts” co-funded by EEA FM (2015-2017), Coordinator: Regional Public Library “P. R. Slaveykov”, Veliko Tarnovo, Partners: IMI—BAS and others;

- Joint research project “Digital libraries implementation in culture and education” (2015-2017) between IMI—BAS and Institute for Computer Science and Control at the Hungarian Academy of Sciences;
- Joint research project “Development of software systems for multimedia and language technologies” (2016-2018) between IMI—BAS and Latvian Academy of Sciences, Latvia Culture college at the Latvian Academy of Culture;
- CIP-ICT-PSP.2009.2.4 Project „EuDML – European digital mathematical library”, EU Competitiveness and Innovation Framework Programme, ICT Policy Support Programme (2010–2013);
- Research project “Development of digital libraries and information portal with virtual exposition “Bulgarian folklore heritage””, Contract №IO-03-03 between IMI—BAS and the National Science Fund of Bulgaria (2006–2012);
- Research project “Digital libraries with multimedia content and its application in Bulgarian cultural heritage”, Contract №8 between the IMI—BAS, and the State Agency for Information Technologies and Communications (2005–2006).

The presented systems and their services aim to provide flexible and effective access and multimedia presentation of the cultural heritage (CH) artefacts and collections, maintaining different forms and format of the digitized information content and rich functionality for interaction. The developments are a result of long-standing interests and work in the technological developments in information systems, knowledge processing and content management systems as constructive components of an innovative ecosystem for digital cultural assets. Long-term research activities aims at creating innovative solutions and building new models, methods and tools for improved use, research and delivery of content in the digital culture ecosystem. We assemble multimedia digital libraries and repositories for collaborative use in specific cultural heritage context, maintaining their semantic/services/users interoperability and creating new functionality for dynamic aggregation of the resources, access improvement, personalization, intelligent curation of content, content protection, innovative technology-enhanced learning, *etc*. The investigations are directed towards

the development of distributed tools for aggregating heterogeneous content and ensuring the compatibility for pan-European access to rich digitized collections of Bulgarian cultural heritage.

This book is a result of collective work of software designers and developers, researchers, CH domain specialists, content managers, *etc*. from the IMI—BAS and its partners, but for the separate chapter writing, the following authors have the main contributions:

- *Chapter 1: Multimedia Digital Libraries in the Innovative Ecosystems for Digital Cultural Assets:* Assoc. Prof. Desislava Paneva-Marinova, Ph. D.;
- *Chapter 2: Ontological Presentation of Orthodox Iconographical Art Domain:* Assoc. Prof. Desislava Paneva-Marinova, Ph. D.;
- *Chapter 3: Services for Content Creation and Presentation in an Iconographical Digital Library:* Assoc. Prof. Desislava Paneva-Marinova, Ph. D., Maxim Goynov, Ph. D.;
- *Chapter 4: Search and Administrative Services in an Iconographical Digital Library:* Maxim Goynov, Assoc. Prof. Desislava Paneva-Marinova, Ph. D.;
- *Chapter 5: Content Analyzing and Synthesizing Services in an Iconographical Digital Library:* Assoc. Prof. Desislava Paneva-Marinova, Ph. D., Maxim Goynov, Ph. D., Assist. Prof. Detelin Luchev, Ph. D.;
- *Chapter 6: Sharing Services in an Iconographical Digital Library:* Assist. Prof. Detelin Luchev, Ph. D., Maxim Goynov, Ph. D.;
- *Chapter 7: Other Classifications of Basic Services in Digital Libraries:* Assoc. Prof. Desislava Paneva-Marinova, Ph. D.;
- *Chapter 8: Standards for Digitized Cultural Heritage, Saved in Digital Libraries:* Assoc. Prof. Desislava Paneva-Marinova, Ph. D., Assist. Prof. Detelin Luchev, Ph. D.;
- *Chapter 9: Implementations of Digital Libraries for Various Cultural Assets:* Assoc. Prof. Desislava Paneva-Marinova, Ph. D., Maxim Goynov, Ph. D., Assist. Prof. Detelin Luchev, Ph. D.

We would also like to thank the book reviewers Prof. Radoslav Pavlov, Ph. D. (IMI—BAS) and Prof. Krassen Stefanov, Ph. D. (Faculty of Mathematics and Informatics, University of Sofia “St. Kliment Ohridski”) for their helpful remarks and advices during the process of preparation of the content of this book.

We would also like to acknowledge our colleagues from IMI—BAS, Laboratory of Telematics, BAS and National Art Academy (Assoc. Prof. Konstantin Rangochev, Ph. D., Assist. Prof. Lilia Pavlova, Ph. D., Assist. Prof. Lubomil Draganov) for our excellent collaboration in the context of all research and development projects, we have been working together for more than 10 years.

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Introduction

During the first decade of the 21st century, information technologies reached levels of development, which allowed new ways to conserve, display and spread out our rich history and the national art and cultural heritage (CH). Contemporary technological solutions such as smart and digital content management systems, virtual museums, galleries and the Internet provided a way to reach, use and preserve this wealth at any time, everywhere and by anyone. Big ecosystems for digital cultural assets using Cloud technologies are created or are in process of active development aiming to store, manage and provide ubiquitously the great diversity of heritage resources. These ecosystems virtually assemble various digital collections, archives, virtual museums, digital libraries (DLs) and cultural heritage sites facilitating the access, reuse and exploitation of digital cultural resources meeting real user needs. The resources are being indexed and semantically annotated in order to be reached in the fastest and easiest way possible; special functionalities and services are being supported for creation of objects and for extracting new data for the existing ones; mechanisms are being provided for automatic update of digital objects and collections; means and services are being created which allow various applications and creative usage (including e-learning, advertising, e-tourism, *etc*.). Systems feature flexibility and decentralization and the access to resources and services is mostly direct or through web-based portals.

Following are some key research questions, raised during the design and the development of these systems:

- How to help the user in exploring the information resources about the chosen domain by offering the most suitable topic-related materials and services: provisioning of suitable and necessary services (improved searching and grouping of resources, creative resource usage), providing automatic simultaneous access to the resources of more than a single system (digital library, repository, archive), flexibility regarding the order of the suggested

information objects, resource recommendation, object reuse, analysis and generation of resources, *etc*.?

- How to describe the selected resources in a given context and to determine the conditions and use cases – cognitive or educational goals, analysis, creative use, *etc*.?
- How to help the user not just to view, but to also gain knowledge?
- How to provide knowledge in the most suitable way and form?
- How to adapt the offered information content for each individual user or group in order to achieve their goals and tasks?
- How to choose the most suitable resources for a specific situation and the method of introduction to the domain, which is subject to research, *etc*.?

The difficulties in solving these research issues are related to the lack of common model and working solutions regarding the basic and the extended functionality, and synchronizing the solutions with the existing standards and regulations in the area; analysis, understanding and better interpretation of digital cultural content; context-dependent use of digital cultural resources; increase and generalisation of visitor experience, contextual techniques for personalising visitor experience, *etc*.

The current research activities of the Institute of Mathematics and Informatics at the Bulgarian Academy of Sciences include the study and applications of new methods and tools for the creation, integration and development of innovative ecosystems for digital cultural assets and their constructive blocks - digital content management systems (*viz.* mainly digital libraries, virtual museum, digital cultural collections). The focus is in researching and exploitation of new or emerging technologies for the development of innovative products, tools, applications and services for the creative digital content production, usage and management. The aim is to transform cultural heritage into digital units, which integration and reuse through research-led methods will have high commercial potential for cultural institutions, tourism, creative and media industries.

There are lots of challenges while working on the given task: a necessity for clear definition of the user's needs of some specific functionality; the presentation of information content in the most suitable way for the chosen user types, the content's ability to be easily found and reached; assuring reusability of the resources in specific context and situation; adapting resources; searching for flexible conceptual solutions, which are easily transferable and implementable via new technological means; synchronization with established standards and specifications, *etc*.

These questions suggest deep research and analysis of the different components of the system – content, user needs, offered services and its applications. The following are of great importance:

- Building of a straightforward model/specification of the activities that the system will serve;
- Developing and introducing proper functionalities for ensuring flexible access to the resources;
- Analysis of the context in which the resources will be used (including educational one) and searching for methodological approaches and techniques for improving the access to the resources to meet the user needs to the highest extent.

Chapter 1 of this book discusses the paradigm of the innovative ecosystems for digital cultural assets, which virtually assemble various digital collections, archives, virtual museums, digital libraries and cultural heritage sites in order to facilitate the access, reuse and exploitation of their digital cultural resources. Special attention is paid to digital libraries as key constructive blocks in the ecosystem for digital cultural assets. Chapter 2 presents the specifics of the concrete CH domain – Orthodox iconographical art, which is the knowledge backbone of the current development. Chapter 2 presents a structure for helping the formal description and documentation of the iconographical art in digital libraries by means of the Semantic web, i.e. ontology of the Orthodox iconographical art. The presented ontology is used for the semantics description and indexing the raw digital content in order to create and maintain reusable

digital objects in a digital library ("Virtual encyclopaedia of Bulgarian iconography multimedia digital library", BIDL) or digital iconographical collections. Chapter 3 briefly describes the overall architecture of digital content management system in a concrete art domain (*viz.* BIDL), covering the main service panels, repositories and their relationships. A detailed overview of the content creation, selection and preview from the architecture, presenting their functionalities and algorithms are discussed in details. In Chapter 4 a special attention was paid to search and administrative services, trying to cover a wide range of possible solutions such as keyword search, extended keyword search, semantic-based search, complex search, search with result grouping, tracking services, exporting data, *etc*. The chapter presents these services, their functional specifications and used algorithms. Chapter 5 presents an extension of the current DL functionality for better content observation and knowledge acquisition through advanced content analysis and synthesizing. The main goal is to reach implicit and hidden data, content, rules and facts, dependences and tendencies, valid for the content in the DL repository, to synthesize and summarize the collected data in order to use it in various investigations and learning. DLs power increases significantly when they use mechanisms for ubiquitous sharing of their e-artefacts and they distribute attractive content in the social networks, reflecting community demands and needs. Chapter 6 presents a service for automatic sharing of iconographical artefacts and full collections from BIDL to selected Facebook communities. In this case, the service is used for widely promoting knowledge about East-Christian iconographical art and culture. The main scopes of Chapter 7 is to make a summarizing overview of the basic Web 2.0 DL services, related to readers, authors, administrators. Chapter 8 briefly describes the main standards, which concern digital cultural content, saved in digital libraries. Chapter 9 presents IMI—BAS's implementations of the digital library management systems for various cultural assets.

Chapter 1: Digital Libraries in the Innovative Ecosystems for Digital Cultural Assets

The great fragmentation of the major sources related to national history and culture in various digital collections, libraries and repositories puts on the agenda the question of providing users with opportunities for their joint consideration and study in order to fully utilize all semantic interconnections between them, overriding physical distance and the specifics of the digital storage of each source. Furthermore, the volume of digital cultural objects and data on them is growing rapidly. Possible approach to solving this problem is linked to the creation of complex semantic-based and context-dependent environments, providing improved use, manage and delivery of large volumes of digital cultural resources.

The paradigm of *ecosystems for digital cultural assets* (also called *digital cultural ecosystems*) appears to respond to these issues and to the growing willingness to share the wealth of cultural resources and continuous research and study of collections and cultural assets. It shows how digital cultural resources can promote creativity and generate innovation in research design and methodology, lead to richer interpretations of the past, bring new perspectives to questions of identity and culture, and generate societal and economic benefits. National cultural heritage can be transformed into digital assets, whose integration and reuse through research-led methods can create value for cultural institutions and heritage, tourism and the cultural and creative industries. The objective is to enhance the analysis of cultural resources to improve our understanding of how national identity can be traced, constructed or debated, and to use those resources to foster innovation across sectors.

The paradigm of digital ecosystems leads to new pro-innovative research for technological provision of humanitarian and social sciences and their contemporary promotion. This will ensure broad multidisciplinary research on cultural heritage in cooperation and co-production of knowledge in various areas and communities of researchers and users.

The European activities in this field are promoted and supported by the Horizon 2020 programme of EC for excellence in research, creating a leading industry and seeking solutions to societal challenges, in particular with the following calls for the period 2014–2020:

- ICT in "Societal challenges" – EC6: Europe in changing world – innovative, inclusive and reflective societies (Reflective societies: cultural heritage and European identities –6-2015: Innovation ecosystems of digital cultural assets; 7-2014: Advanced 3D modelling for accessing and understanding European cultural assets; Social Platform on Reflective Societies);
- ICT in „Interfaces, Content & Data" - CULT-COOP-09-2017 - European cultural heritage, access and analysis for a richer interpretation of the past; ICT-19-2017: Media and content convergence; ICT-20-2017: Tools for smart digital content in the creative industries; ICT-14-2016-2017: Big Data PPP: cross-sectorial and cross-lingual data integration and experimentation;
- ICT in "Leadership in Enabling and Industrial Technologies" – Content technologies and information management - ICT19-2015: Technologies for creative industries, social media and convergence, *etc*.

The several research and innovation projects are successfully evaluated and are starting in 2016, for example: I-Media-Cities - Innovative e-environment for Research on Cities and the Media (I-Media-Cities, 2016), ARCHES - Accessible Resources for Cultural Heritage EcoSystems (ARCHES, 2016), ArchAIDE - Archaeological Automatic Interpretation and Documentation of cEramics (ArchAIDE, 2016), CROSSCULT - Empowering Reuse of Digital Cultural Heritage in Context-aware Crosscuts of European history (CROSSCULT, 2016). In particular, the activities under this topic aims to:

- "stimulate new research perspectives for the humanities and social science communities, promote further the use of digital cultural heritage allowing its reinterpretation towards the development of a new shared culture in Europe;

- provide innovative and creative methods for approaching cultural assets and generate applications and services to access and exploit the rich and diverse European digital cultural heritage in a sustainable way;
- foster collaboration between those with primary expertise in the interpretation of cultural data and researchers with complementary expertise in digital and interactive frameworks."

Horizon 2020 call REFLECTIVE-6-2015 (REFLECTIVE-6-2015, 2015) supports and promotes access to and rescue of digital cultural heritage resources (available in scientific collections, archives, museums, libraries and cultural heritage sites) as part of research and innovation. Projects should enable new models and demonstrations of the analysis, interpretation and understanding of Europe's cultural and intellectual history and/or capitalising on state of the art technologies (*e.g.* mobile and wearable devices), bring cultural content to new audiences in novel ways, through the development of new environments, applications, tools, and services for digital cultural resources in scientific collections, archives, museums, libraries and cultural heritage sites. The developed technologies or services should be generated in the context of humanities research perspectives (identity, culture, questions of place, historical and cultural knowledge) and/or facilitate the access, reuse and exploitation of digital cultural resources meeting real user needs.

Bulgarian academics have demonstrated considerable interest in this area in recent years. The main efforts are concentrated in applied aspects, especially for increasing the presence of digital artefacts and collections of the Bulgarian cultural and historical heritage in the global information space. Besides, work is done towards developing ICT tools and systems for digital presentation and preservation of cultural heritage artefacts. There is also intensified interest in fundamental research (priority areas of *Informatics, ICT and Cultural Heritage* of the *Strategy for the Development of Science in Bulgaria till 2020, Innovation Strategy for Intelligent Specialisation, Horizon 2020*, *etc*.) in search of innovations especially in areas/subareas relevant to data processing, access control, intelligent supervision, security, semantics, *etc*.

Current work is concentrated on specific subareas, assisting the resolving of these issues in Bulgaria:

- Creating models and methods for improved context-based access and management of digital knowledge and collections related to cultural heritage;
- Building a conceptual model of a multifunctional digital culture ecosystem, based on the latest concepts, approaches and solutions in the area;
- Modelling tools for interoperability between constructive blocks in an digital cultural ecosystem;
- Creating models for efficient use and continuing development of the digital culture ecosystem.

It is a key assumption that improved use, research and delivery of knowledge and collections related to cultural and historical heritage and the overall structuring of a digital culture ecosystem software environment by a referential model will help addressing some of the problems with handling large volumes of digital cultural data and objects, as well as their dynamic interaction in the system. Current problems will be overcome, such as data loss due to lack of uniform structures; lack of uniform interpretation; insufficient attractiveness of presentation; lack of unified access to many different digital repositories of cultural and historical heritage; poorly adaptive and customizable presentation of objects; difficulties in context-based use; *etc*. Furthermore, technology transfer to the technical and social sciences and the humanities, as well as the innovations in these areas, will be greatly encouraged.

Moreover, the research community has to deal with important issues of handling data directly affecting the economy (as represented by creative and recreational industry), the public sector (cultural institutions—museums, libraries, galleries, *etc*.), education, public processes, human resources, *etc*.

Digital Libraries in the Digital Cultural Ecosystems

The innovative ecosystems for digital cultural assets virtually assemble various digital collections, archives, virtual museums, digital libraries and cultural heritage sites in order to facilitate the access to their resources, bringing cultural content to new audiences in novel ways.

In the nature, an ecosystem is an area where organisms interact with one other as well as with the non-living parts of the environment. In the digital cultural ecosystem, various "digital organisms" (*viz.* collections, archives, virtual museums, digital libraries, cultural heritage site, *etc*.) also interact with one other as well as with the living part of the environment (*viz.* users). A digital cultural ecosystem can be huge, covering one country or a region (similarly to a large forest or lake in the nature), but it can be small, such as a virtual museum or a private collection of artefacts (the nature analogues, a puddle of water or only a tree). "Digital organisms" work through their services and tools to satisfy and interact with their users.

We determine *digital libraries* as *key constructive blocks in the ecosystems for digital cultural assets*, which demonstrate appropriate services and tools of re-using and repurposing digital assets, paving the way for wider exploitation of cultural resources and boosting innovation. We accept them as "virtual plants" with diverse purposes and functions in the digital ecosystem.

In the past digital libraries were isolated and monolithic systems limited to access to content of a single provider. The development of the technologies during the last years provides new functionalities and advanced services to contemporary digital libraries transforming their static complex structures to environment with a dynamic federation of functional units. This change resulted from the needs of the market, the emergence of new technologies, and especially from the request for stricter use of the existing resources and adapting DLs content and services to the needs of different user groups.

Digital libraries could provide powerful and efficient functionalities for content management (acquisition, storage, indexing, access, and maintenance), manifold metadata for content enrichment, and structuring, as well as services for effective content search, access, annotation, filtering, and dissemination. The DL content and services are determined by acquisition (collection development), organization, and access policies tailored to the users the DL is intended to serve. In (Paneva, Pavlova-Draganova, & Draganov, 2005) the following basic characteristics of digital libraries are specified:

- Ability to share information;
- New forms and formats for information presentation;
- Easy information update;
- Accessibility from anywhere, at any time;
- Services available for searching, selecting, grouping and presenting digital information, extracted from a number of locations. Contemporary methods and tools for digital information protection and preservation;
- Ability to use different types of computer equipment and software;
- No limitations related to the size of content to be presented.

As constructive blocks of the ecosystems for digital cultural assets, DLs demonstrate also advanced solutions for:

- Intelligent content curation;
- Context-based content usage, automatic contextualization and identification of content;
- DL usage for research, e-learning/e-training, applied games/gamification, animation/simulations, mobile applications, *etc*.;
- Personalization, user experience design and aesthetics;
- Real-time adaptable and interactive visualization, end user centric visualization;
- Linked data and semantic analytics;
- Multimodal interfaces providing improved user's experience, *etc*.

The DL contemporary vision is related to the development of tools and services for innovative usage and better user interaction with their digital cultural assets. Thus, DLs will allow the content reinterpretation, study, understanding and analysis, creative use/re-use and remix (for new art projects, *incl.* documentaries and performance) and exploitation towards the development of a new shared and linked digital heritage culture for new knowledge around cultural heritage.

The focus of this study are the basic functionality and services in multimedia digital libraries in specific CH domains, as demonstrations of solutions for optimized content management and usage.

Chapter 2: Ontological Presentation of Orthodox Iconographical Art Domain

In the recent years, the Orthodox (East-Christian) iconographical art works have been digitized providing a large volume of data. The need for effective classification, indexing and retrieval of iconography repositories was the motivation of the design and development of a systemized ontological structure for description of iconographical art objects. This chapter presents the ontology of the East-Christian (Orthodox) iconographical art, developed to provide content annotation in BIDL. The ontology's main classes, relations, facts, rules, and problems appearing during the design and development are described. It also discusses problems appearing during the ontology design and development and used approaches for domain formalizing.

Orthodox iconographical art is recognised as one of the most significant areas of the art of painting. Until recently, it had been neglected in the digital documentation and the registry of the art of painting. But the accessibility to this valuable part of mankind's cultural and historical ancestry was enhanced greatly with the appearance of the *BIDL* in the world virtual space. This Internet-based environment becomes a place where iconographical objects (IOs) of different kinds and origins were documented, classified, and "exhibited" in order to be widely accessible to both professional researchers and the wide audience. Rare specimens, private collections, icons from difficult-to-access storages, distant churches, chapels, and monasteries, objects in a risk environment or unstable conditions, *etc*. are appearing for new e-exposition. The library provides services for registration, documentation, access and exploration of a practically unlimited number of Orthodox iconographical artefacts and knowledge (Pavlov, Pavlova-Draganova, Draganov, & Paneva, 2006) and the end users can use this rich knowledge base through its interactive preview, objects complex search, selection, and group. A complete description of the BIDL functionality is made in (Pavlova-Draganova, Paneva-Marinova, Pavlov, & Goynov, 2010).

BIDL digitally preserves:

- Hundreds of specimens of Bulgarian icons from different artists, historical periods, and schools, and their detailed description;
- Techniques of the iconography;
- Description of significant iconographic schools of The Renaissance—introduction of works and authors;
- Biographies of known iconographic artists;
- A glossary of terms.

The presented icons originate from the end of the twelfth to the beginning of the twentieth centuries and the majority of them belong to the Bansko-Razlog iconographic art (around 80 icons, XVIII, XIX, XX century). Icons from the main schools and regions of Bulgaria (Triavna iconographic school, Samokov iconographic school, icons from Veliko Tarnovo, Sozopol, Rila Monastery, Arbanasi, *etc*.) are presented. The digital objects are grouped into thematic collections according to their topics, period, authors and other criteria. The artefacts and valuable knowledge for the Orthodox iconographical art revives after its e-publishing in BIDL, but the necessity for wider distribution and promotion remains. Moreover, the library is used in several cross-media, ubiquitous and technology-enhanced learning applications (Paneva-Marinova, Pavlova-Draganova, Draganov, Pavlov, & Sendova, 2009) (Paneva-Marinova & Pavlov, 2011) (Paneva-Marinova, Pavlova-Draganova, Pavlov, & Sendova, 2008) (Draganov, et al., 2015) (Luchev, et al., 2016) (Bontchev, Paneva-Marinova, & Draganov, 2016).

Presentation of East-Christian Iconographical Art Semantics

The need for effective retrieval of the icons of East-Christian iconographical art in BIDL is motivated by the increasing number of digitized iconographical objects. For the solution of this problem we develop a domain ontology for the East-Christian iconographical art. This ontology is used for the semantic metadata description and

indexing of the iconographical art content. Similar work is done in (Tzouveli, et al., 2008) (Tzouveli, Simou, Stamou, & Kollias, 2009). It defined a semantic classification for the Byzantine icons. This classification is used division of icons into semantic regions in order to provide face detection, analysis of the facial characteristics and sacred figure recognition.

The conceptualization and formal presentation of the iconographical art semantics posed specific challenges for our team of ontologists, art domain specialists and BIDL content creators. Several problems in "Icons" domain formalization appeared (Pavlova-Draganova, Paneva-Marinova, & Pavlov, 2011). These challenges are mainly related with:

- Determining the set of separate ontological sub-structures of the iconographical object domain, the iconographic school, the author of iconographical objects, the iconographic character/scene, *etc*.;
- Determining in a unique way the descriptors of the different types of iconographical objects (icon, wall-painting, miniature, plastic iconographical object, *etc*.) according to accepted canons of Orthodox painting;
- Reducing the complexity of the structures that describe different aspects of the iconographical object domain (especially for technological specifics, hierarchy of characters, descriptions of scenes, *etc*.) without loss of important content;
- Presenting relations between classes and constructing their complete network;
- Defining in unique way the domain rules, axioms, constraints and facts (because of the incompleteness, inaccurateness or subjectivity of the existing information presenting the iconographical art domain);
- Creating standardized and consistent descriptions of iconographical objects following the available standards for cultural heritage content presentation.

In our ontological model the iconographical art world is described by three "thematic entities" (also called levels of knowledge) (Pavlova-Draganova, Paneva-Marinova, & Pavlov, 2011). Each of these entities is enriched with a set of sub-levels, covering a wide range of characteristics. The first one is the "Identification" entity,

which consists of general data identifying aspects of the iconographical object (IO) such as IO title, type, author, author's clan and biography, iconographic school, period, dimensions, current location and source, and IO object identification notes (for example, distinctive features, possession (private or museum collection/s), inventory number, author's signature, donor inscriptions, *etc*.), and iconographic school description (see Figure 1).

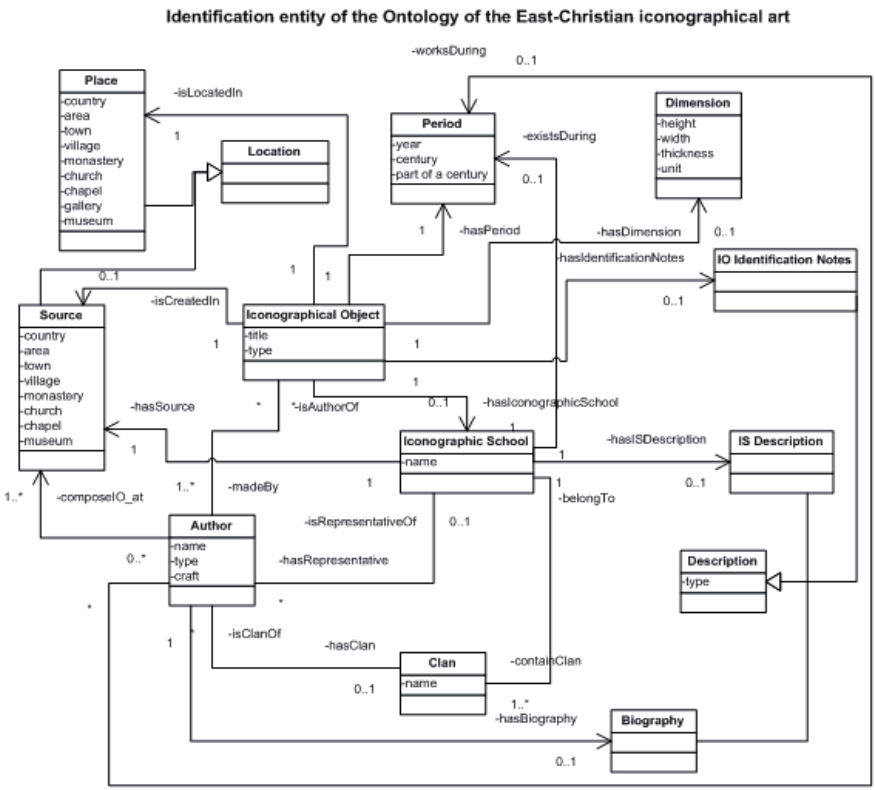


Figure 1: Identification entity of the ontology of the East-Christian iconographical art (Pavlova-Draganova, Paneva-Marinova, & Pavlov, 2011)

The second entity (see Figure 2) covers information concerning the descriptive details of the theme and forms of representation, providing a better understanding of the content. The main concepts included are: depicted character/s, iconographical scenes, character/s in the scene/s, symbol/s in the scene/s, characters' gestures, characters' vestment, detailed description of the depicted content, *etc*.

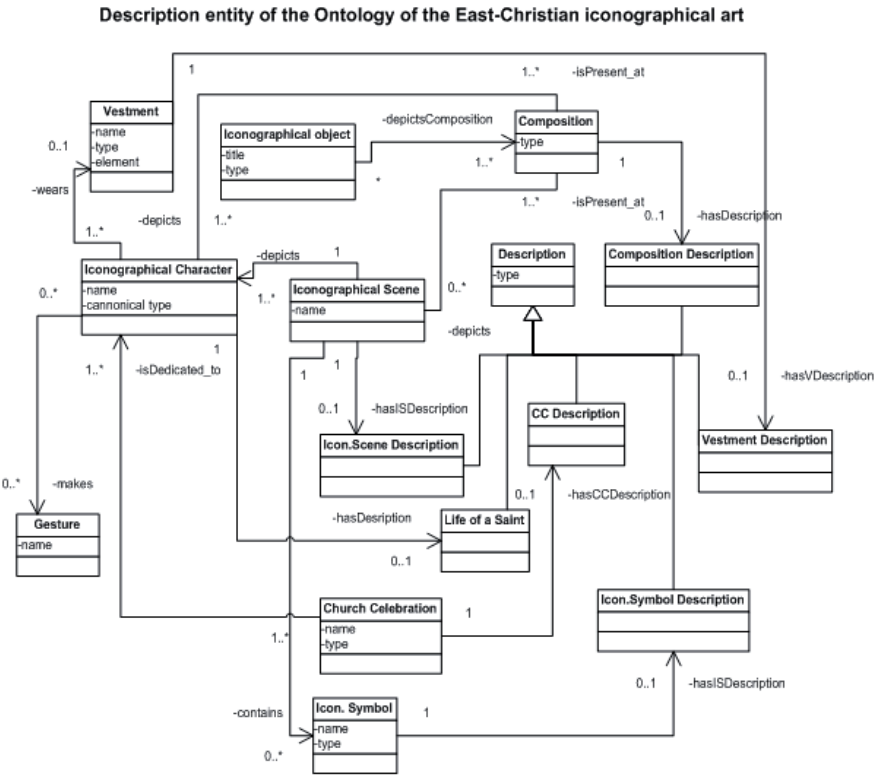


Figure 2: Description entity of the ontology of the East-Christian iconographical art (Pavlova-Draganova, Paneva-Marinova, & Pavlov, 2011)

The third entity (see Figure 3) includes technical information revealing iconographic techniques, base materials, gildings, repousse covers, *etc*., used in the

creation of the iconographical object/collection, and also concerning examinations of the condition, such as diagnosis or history of the conservation treatment (Pavlova-Draganova, Paneva, & Draganov, 2007).

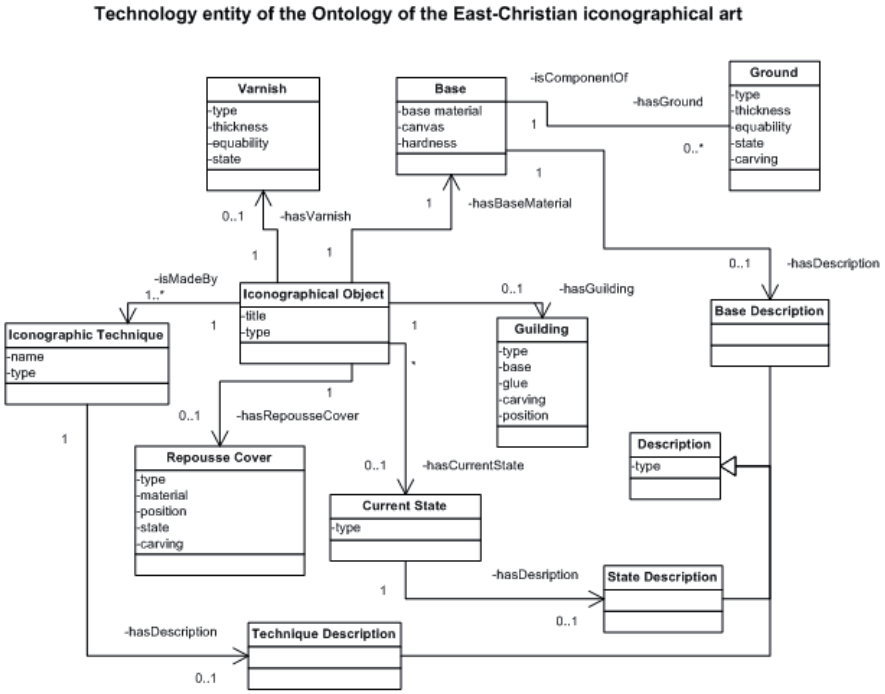


Figure 3: Technology entity of the ontology of the East-Christian iconographical art (Pavlova-Draganova, Paneva-Marinova, & Pavlov, 2011)

In the ontology several rules and facts are defined. For example, the following statement determines the dependence between the *Author* of an *Iconographic School* and the value of the *Period* in which he worked.

> If *Author* isRepresentativeOf *Iconographic School* = A then the *Author* works during *Period* p for the *Iconographic School* A.

For example, if we have an unknown author from Bansko-Razlog iconographic school we could periodize its works (in identity search).

The next example tracks the relation between the *Iconographic Scene* and the depicted *Iconographical Character(s)* on it.

> If *Iconographic Scene* = A then *Iconographic Scene* depicts *Iconographical Character* = $\{a_1, a_2, ..., a_n\}$, where $\{a_1, a_2, ..., a_n\}$ is predefined set.

Similar statements are made for the *Vestment* and *Gesture* of the *Iconographical Character* in the *Iconographic Scene* and the depicted *Iconographical Symbol*. The *Iconographical Character* itself also has similar dependencies with its *Vestments, Gestures* and *Iconographical Symbol*. These rules could aid the annotation action in the library. When these rules are clearly indicated in the annotation objects template, the relevant concept class value[1] could be filled automatically or could be proposed to be chosen for different painting interpretations (i.e. one annotation value could be used for several similar objects). These rules could also give possibilities for some inferences[2] about the emphasis, trends, and priorities in the work of an author, an iconographic school or the art during a fixed period. These rules of the description entity of the ontology are defined according the canons of the Orthodox painting described in special technology guides (manuals) on the so called *Ermeniya*[3] of icon painting.

We also determined a set of rules and facts for dependence between *Iconographical Object type* and the *Iconographic Technique types,* the *Base,* the *Gilding and* the *Repousse Cover type* for its production; the *Iconographic School* and the *Period, Source town, village* and *area*; temporal and spatial dependences, *etc*.

1 For example, values of the Iconographical Character and its Vestments, *etc.*

2 For example, for finding main characters depicted on the Iconographic Scene "Deisis with Apostles" or typical/different Vestments, Gestures or Iconographical Symbols depicted, *etc.*

3 Ermeniya (Ερμηνεία from Greek) are those "hidden" books, used by painters to help them follow the canons and the technology of the iconography. They trace the sequence of actions to create iconographical objects (main techniques, grounds, pigments, plating techniques, *etc.*, as well as the way they are prepared); the painting in the icon with its specifics and symbols, the way to fix it to the foundation, measures, proportions, prescriptions, *etc.* For example: the ermeniya of Zakharij Petrovich, the ermeniya of Dicho Zograf, *etc.*

These statements could be used for critical analysis of technology/art, learning, inferences for trends and priorities in the domain, finding implicit data/content, dependences, tendencies, *etc.*

The interpretations of the iconographical knowledge are not considered isolated from the standards and specifications in the field of representation of cultural information because the goal is to maximize the reusability and portability of the designed ontological model. The most significant new development is the CIDOC Conceptual Reference Model (CRM), "object-oriented domain ontology" for expressing implicit and explicit concepts in the documentation of cultural heritage. During the creation of the "East-Christian iconographical art" ontology we observe the conceptualization approaches of CIDOC CRM ontology. We use part of its concepts and properties in our ontology. We extend another part in order to make it fit the iconography domain. For example, our "Iconographical Object" class is a sub-class of CIDOC CRM E22–Man-Made Object, our "IO Author" is CIDOC CRM E21 – Person, our "Clan" is CIDOC CRM E74 – Group, *etc.* The juxtaposing approach and a rich set of examples are included in (Paneva, Pavlova-Draganova, & Draganov, 2007).

The main entities and the corresponding metadata values in the ontology are supported, documented and provided by the scientific diagnosis, which has been applied to the iconographical objects and collections. The main knowledge sources for the Bulgarian iconography domain are (Bosilkov, 1989) (Petrov, 1978) (Prashkov, 1985) (Matakieva-Lilkova, Bulgarian icon, 1994) (Matakieva-Lilkova, 2001).

To represent efficiently the iconographical annotation framework and to integrate all the existing data representations into a standardized data specification, the "East-Christian iconographical art" ontology needs to be represented in a format (language) that does not enforce semantic constraints on iconographic data, but can also facilitate reasoning tasks on this data using semantic query algebra. This motivates the representation of these ontological model in Web Ontology Language (OWL). OWL facilitates greater machine interpretability of Web content than that supported by XML, RDF, and RDF Schema by providing additional vocabulary along with a

formal semantics. Knowledge captured from iconographic data using OWL is classified in a rich hierarchy of concepts and their inter-relationships. OWL is compositional and dynamic, relying on notions of classification, reasoning, consistency, retrieval and querying. We investigated the use of OWL for making our ontology using Protégé OWL Plug-in.

Conclusion

This chapter presented a structure for helping the formal description and documentation of the iconographical art in digital libraries by means of the Semantic web. By now, hundreds of objects are annotated with the ontology of the East-Christian iconographical art in BIDL and learning analysis using its conceptualization framework is performed in a real eLearning process in the SINUS project (SINUS-Project, n.d.).

The presented ontology could also be used in different areas such as automatic sacred figure recognition, iconographic scene recognition and content analysis, painting technology analysis (technological point of view), dynamic personalized creation of content in the Iconography domain, matching the iconography of different interpretations of the same characters or scenes, identifying icons in risk environments, storage, preservation and promotion of our art and iconographic heritage, *etc.*

Future work on the East-Christian iconography domain will include the extension of its current formal specification with conceptualization of churches, monasteries, *etc.* repositories of iconographical artefacts, church plates; ethnographic objects used for idolatry, *etc.* Thus, the target domain will be completely presented and formalized and will provide tools for profound observations and interdisciplinary research.

Chapter 3: Services for Content Creation and Presentation in an Iconographical Digital Library

Content creation and presentation are key activities in a multimedia digital library (MDL). The proper design and intelligent implementation of these services provide a stable base for overall MDL functionality. This chapter presents the framework and the implementation of these services in the latest version of the *Virtual encyclopaedia of Bulgarian iconography* multimedia digital library. For the semantic description of the iconographical objects, a tree-based annotation template is implemented. It provides options for auto completion, reuse of values, bilingual entering of data, automated media watermarking, resizing and conversing. The chapter describes in detail the algorithm for automated appearance of dependent values for different characteristics of an iconographical object. An algorithm for avoiding duplicate image objects is also included. The service for automated appearance of new objects in a collection after their entering is included as an important part of the content presentation. The research follows the accepted vision for simplifying and speeding up of the chosen activities, and the provision of easy navigation and knowledge tracing during the browsing of content.

BIDL Architecture

The latest tendencies of the development of multimedia digital libraries are towards transforming their static complex structures to systems with a dynamic federation of functional units. This change resulted from the needs of the market, the emergence of new technologies, and especially from the request for stricter use of the existing resources and adapting MDLs content and services to the needs of different user groups. In relation to this, the design of the architecture of the recent version of BIDL is based on the service approach and aims to provide a decentralized, multi-functional, flexible, dynamic and easily transformable structure of the developed

environment. The architecture of BIDL contains two main service panels, *Object data management* and *Administrative services* (see Figure 4), joined to a *Media Repository* and a *User Profile Repository*.

The *Object data management* panel refers to the activities related to:

- Content creation: add (annotate and semantic indexing), store, edit, preview, delete, group, and manage multimedia digital objects; manage metadata;
- Search, select (filter), access and browse digital objects, collections and their descriptions.

The *Administrative services* panel mainly provides user data management, data export and tracking services. User data management covers the activities related to registration, data changes, level set, and tracking of the user (Paneva-Marinnova, Pavlov, Goynov, Pavlova-Draganova, & Draganov, 2010).

The export data services provide the transfer of information packages (for example, packages with MDL objects/collections, user profiles, *etc.*) compatible with other database systems. For example, with these services a package with MDL objects could be transported into an XML-based structure for new external usage. The tracking services have two main branches: tracking MDL objects and tracking MDL users' activities.

The tracking of MDL objects monitors the activities of add, edit, preview, search, delete, select, and group MDL objects/collections in order to provide a wide range of statistical data (for frequency of service use, failed requests, *etc.*) for internal use and generation of inferences about the stability and the flexibility of the work and the reliability of the environment. The tracking of MDL users' activities monitors user logs, personal data changes, access level changes and user behaviour in the MDL.

For every MDL object all semantic and technical metadata are saved in the Media repository. These metadata are represented in catalogue records that point to the original media file/s associated to every MDL object.

The User profile repository manages all user data and their changes.

There are several internal relations between the separate components in the service panels. For example, in the Object data management panel:

- The *Add object services* are related to the *Preview* and *Edit services*;
- After the Preview (services), the *Edit* or *Delete* services can be executed;
- The *Search object services* point to *Preview, Edit, Delete* and *Group* objects services;
- The *Group objects services* are related to Preview services;
- After the *Edit (services*), the *Preview services* can be executed.

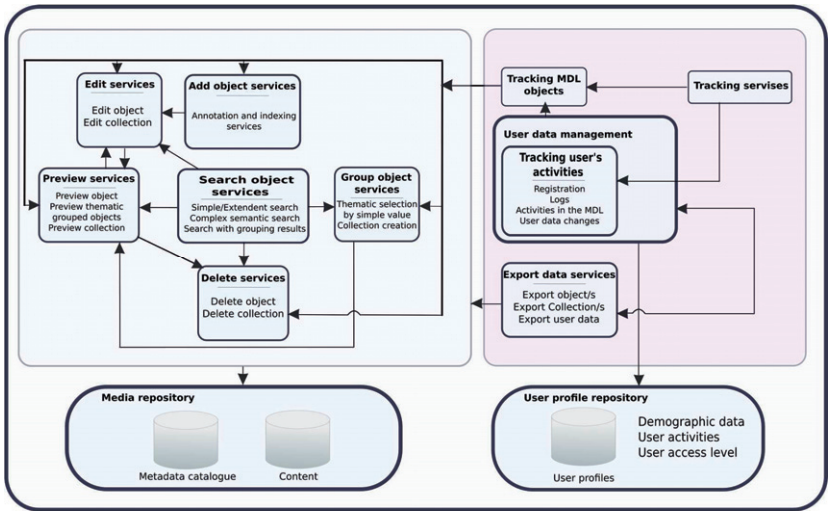


Figure 4: BIDL Architecture

There are several relations between the components of the two main service panels, for example, the *Tracking of MDL objects* from the Administrative services panel is connected to *Add object, Preview, Delete, Search, Edit* and *Group services* from the Object data management panel.

All existing internal and external relations for the service panels provide the internal interoperability and the flexibility of the library.

Content Creation

The main part of the content creation process is the annotation and semantic indexing of digital objects in order to add them to the library repositories. The entering of technical and semantic metadata for a multimedia digital objects in the BIDL is implemented through different automated annotation and indexing services.

The technical metadata, expressed in Dublin Core, are attached to every multimedia object automatically. They cover the general technical information, such as file type and format, identifier, date, provider, publisher, contributor, language, and rights.

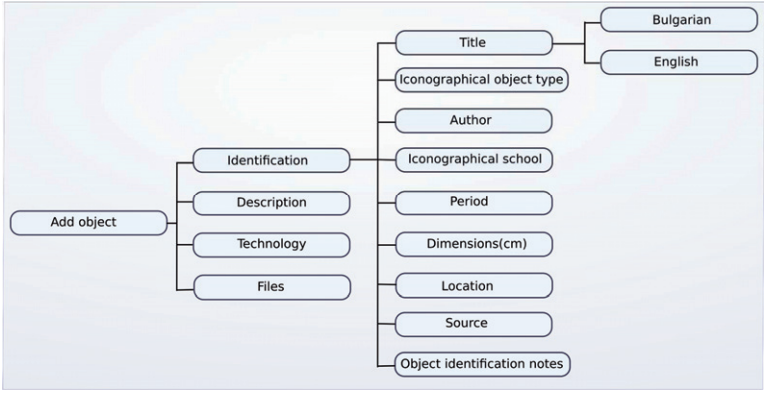
An annotation template is implemented for the semantic description of iconographic objects. The template provides several options for easy and fast entering of metadata:

- Auto completion services: all used (already entered) field values are available in a special panel for reuse (see Figure 5);
- Bilingual data entering with automated relation between the relevant values in different languages (see Figure 5);
- Automated appearance of dependencies coming from the relations of the defined classes' (concepts) in the Ontology of East Christian iconographical art (all main relations and rules expressed in the iconographical ontological structure are incorporated during the development of the annotation template);

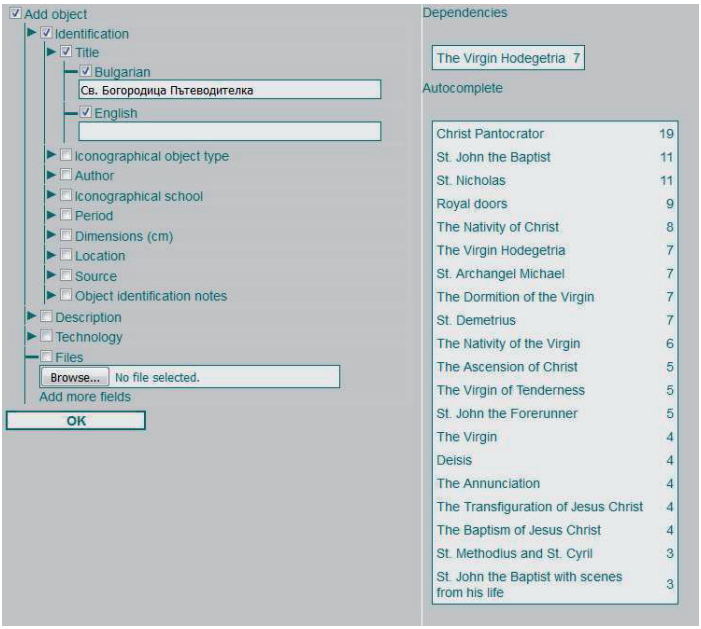
Example: If the value of the field **Region** is *Blagoevgrad*, when we start to complete the field **Town/Village**, all the available values in the MDL for towns/villages in the Blagoevgrad region will appear and can be selected by the annotator. All new field values are available for use after their first entering.

- Automated appearance of the number of the used field value, providing regular data tracking (see Figure 5);
- A tree-based structure of the annotation template. Only checked fields are displayed for entering metadata (Figure 5);

- Possibility for adding more than one media for one metadata description in order to create rich multimedia digital objects;
- Reuse of an already created annotation for new iconographical objects: the new media object has to replace the older one, the annotation is kept and the new iconographic object appears after saving;
- Automated watermarking of the image and video objects;
- Automated resizing of the image and video objects;
- Automated identification of file formats;
- Automated conversion of the audio, video and text objects in a format suitable for Web-preview.



(a)



(b)

Figure 5: Part of the annotation template of an iconographical object (Pavlova-Draganova, Paneva-Marinova, Pavlov, & Goynov, 2010)

After saving a new iconographical object, a special machine tracks for the appearance of dictionary terms in the object data. If some terms are available the machine adds links to their explanations. In the case of entering a new dictionary term, its presence in the available objects is discovered automatically and a link is added.

In order to avoid duplicate image objects a service that checks the similarity between images is provided. The next part presents its algorithm.

Caching Images for Optimizing their Compare

1. All images are resized to $n \times n$ pixels. So we get the following matrix:

$$p = \begin{pmatrix} p_{11} & p_{12} & \dots & p_{1n} \\ p_{21} & \dots & \dots & p_{2n} \\ \dots & \dots & \dots & \dots \\ p_{n1} & \dots & \dots & p_{nn} \end{pmatrix}$$, where p_{ij} are pixels, each of them with values of red, green and blue ($p_{ij} = \{r_{ij}, g_{ij}, b_{ij}\},\ 0 \le r_{ij} \le 255, 0 \le g_{ij} \le 255, 0 \le b_{ij} \le 255$)

2. Create M (Going to grayscale)

$$M = \begin{pmatrix} m_{11} & m_{12} & \dots & m_{1n} \\ m_{21} & \dots & \dots & m_{2n} \\ \dots & \dots & \dots & \dots \\ m_{n1} & \dots & \dots & m_{nn} \end{pmatrix},\ m_{ij} = k_1 r_{ij} + k_2 g_{ij} + k_3 b_{ij}$$

k_1, k_2, k_3 are coefficients for translating from RGB to grayscale.

Standard coefficients are $k_1 = 0.3, k_2 = 0.59, k_3 = 0.11$, $0 \le m_{ij} \le 255$, so $\sum_{i=1}^{3} k_i = 1$

3. Create the series (row) $M_1 = \{m_{11}, m_{12}, \dots, m_{1n}, m_{21}, \dots, m_{nn}\}$

Sort M_1 in ascending order and find the middle element(s). If n is even, then the middle element is m_j, where $j = (n^2 + 1)/2$ in the sorted series $M_1 = \{m_1, m_2, \dots, m_{n^2}\}$ and the average value is $m = m_j$. If odd, then the middle elements are m_{j_1}, m_{j_2}, where $j_1 = n^2/2$ and $j_2 = (n^2/2) + 1$ and the average value $m = (j_1 + j_2)/2$.

Now, create

$$B = \begin{pmatrix} b_{11} & \dots & \dots & \dots \\ \dots & \dots & \dots & \dots \\ \dots & \dots & \dots & \dots \\ \dots & \dots & \dots & b_{nn} \end{pmatrix}$$, where $b_{ij} = \begin{cases} 1, m_{ij} > m \\ 0, m_{ij} \le m \end{cases}$

The matrix B is our cache for an image object.

Now, we can compare it to the caches of other objects and find the level of match (in %).

In our current case we use $n = 64$. So the cache size is 64×64 bits, which makes 4096 bits or 512 bytes. This small cache size guarantees us good performance when comparing images.

The presented service does not use any previously created technical metadata for the images during their comparing. Similar service could be implemented by comparing the MPEG7 metadata descriptors for the selected media objects. This solution is not applicable in our case because of the absence by default of metadata about the media (images).

An important task is also the provision of automated appearance of dependent values for different characteristic about an iconographical object. The following algorithm is used:

Let p_i be an iconographical object, and $p = \{p_1, p_2, ..., p_n\}$ be the set of all iconographical objects.

Let m_i be a characteristic describing the iconographical object, and $M = \{m_1, m_2, ..., m_k\}$ be the set of all possible characteristics.

Let us define the function $d(m_i)$, $d(m_i) \in M_0$, where $M_0 = M \cup \{Ø\}$, $Ø$ is the empty element.

$d(m_i) = m_j$ means that the characteristic m_i depends on m_j.

Let $O = P \times M, \{(p_i, m_j) \in O |$ the object p_i has the characteristic $m_j\}$

Let $v(p_i, m_j) = v_0$ be a function, which returns the value v_0 of the characteristic m_j for the object p_i.

When we define a value for a characteristic m_j of object p_i, the following algorithm steps are executed to choose possible dependent values for us:

1. Find $d(m_i)$

   IF $d(m_i) =$ Ø THEN Go to 7. (End. No Dependencies found.)

ELSE $m_k = d(m_j)$

2. Find $v' = v(p_i, m_k)$
3. Find all $p : v(p, m_k) = v'$, $P' = \{p | v(p, m_k) = v'\}$
4. Create the series $V = \{v(p, m_j)\}\ \forall p \in P'$
5. IF $V = \{\}$ THEN Go to 7. (End. No dependencies found.)
6. Sort V by the frequency of the values and remove repeated values. V contains all possible dependencies.
7. End.

Content Presentation

During the development of the content presentation services, a profound analysis was made of content selection and preview possibilities in order to satisfy the user's needs. First we had to determine the preview possibilities of a separate iconographical object and its components and after that the preview of grouped objects.

The visualization of the rich semantic description of the separate iconographical object is determined through hidden parts appearing in a new window after link selection. This possibility is used mainly for the long author's biography/school descriptions and for the dictionary terms. Parts of the descriptive data field are also hidden, but their values are available for searching in special forms.

The left frame of the preview window shows the description of the iconographical object. In the right frame, the media/s object/s is/are situated. There appears a link to the original media source. The shown media object is stamped through watermarking technique.

During the development of object grouping services the main iconographic ontology classes are selected as object grouping criteria. For example, there can be a preview of the available iconographical objects, grouped according to their title, author, iconographic school, used technique or base material. Using another grouping

option the user can see separately a list of all iconographic school, and selecting one of them he can see the available collections (see Figure 6). A similar preview is available for the authors and regions/towns of physical object location.

The grouping option related to the presented content is implemented by the grouping of objects by depicted iconographic scenes, characters or canonical character types. Their presentation is based on the taxonomies of iconographical characters and iconographical scenes expressed in the ontology of East Christian iconographical art.

Every user can create his own collection of selected objects after search activity. Rich search possibilities are available in order to assist collection creation. The user can write the collection's title and short description. He can also select its status: private or shared with other users.

Figure 6: Iconographical objects grouped by an iconographic school (*viz.* Tryavna iconographical school)

New objects for a collection appear automatically after their entering. This service uses the following rule:

Let $P = \{p_1, p_2, ..., p_n\}$ be the set of all iconographical objects.

Let $A_m = \{a_{m1}, a_{m2}, \ldots, a_{mk}\}$ be the set (also called a collection) with *k* iconographical objects with a selected characteristic *m*, $A_m \subseteq P$.

Let p_{ti} be a new iconographical object, added to the library, $P = P \cup \{p_{ti}\}$.

IF $t \equiv m$ THEN $A_m = A_m \cup \{p_{ti}\}$

Let $M = \{m_1, m_2, ..., m_r\}$ be a set of characteristics for a collection $A_M = \{a_{M1}, a_{M2}, ..., a_{Mk}\}$ with *k* iconographical objects.

Let p_{ti} be a new iconographical object, added to the library, $P = P \cup \{p_{ti}\}$, and $M' = \{m_1', m_2', ..., m_r'\}$ be its set of characteristics.

IF $M \subseteq M'$ THEN $A_M = A_M \cup \{p_{ti}\}$

The home page of the library contains a panel with last visited objects, aiding the user's observation of the content. This service uses the following algorithm:

Let p_i be an iconographical object, and $P = \{p_1, p_2, ..., p_n\}$ be the set of all iconographical objects.

Let t_j be the time an object was visited $T = \{t_1, t_2, ..., t_m\}$

$Q = P \times T$

(p_i, t_j) means that the object p_i was visited at the time t_j.

Steps of the algorithm:

1. Create series $Q' = \{(p_{i_1}, t_{j_1}), (p_{i_2}, t_{j_2}), ..., (p_{i_d}, t_{j_d})\}$, where $t_{j_1} > t_{j_2} > .... > t_{j_d}$
2. Remove all (p_{i_k}, t_{j_k}), where $\exists t_{j_l} : l < k \;\&\; p_{i_k} \equiv p_{j_l}$
3. Select first $\{q_1, ..., q_v\} \in Q'$.

Conclusion

The rising new generation of information technologies is gradually alienated from the software as a basic term and starts to consider mainly the services and functionalities offered to the users. The important services in the contemporary digital libraries are: content creation, crawling, storage, browse, measurement, retrieval, classification/ categorization, filtering, clustering, summarization, mining, preservation, decision support, user modelling/ personalization, *etc.* A main task for the developers is the proper design and intelligent implementation of these services. In this chapter we presented the architecture of implemented in the "BIDL services and we made a detailed overview of a part of them. The design and the implementation of the described services result from a long-term observation of the users' preferences, cognitive goals, needs, object observation style, and interests, made during the testing processes of the previous versions of the BIDL. The main goal was the satisfaction of users' preferences and needs with appropriate navigation, visualization and content presentation techniques.

Chapter 4: Search and Administrative Services in an Iconographical Digital Library

In this chapter a special attention is paid to search and administrative services, trying to cover a wide range of possible solutions such as keyword search, extended keyword search, semantic-based search, complex search, search with result grouping, tracking services, exporting data, *etc.* It presents these services in detail, their functional specifications and used algorithms.

Search Services

BIDL provides a wide range of search services, such as keyword search, extended keyword search, semantic-based search, complex search, and search with grouping results (Paneva-Marinnova, Pavlov, Goynov, Pavlova-Draganova, & Draganov, 2010). This part presents the complex search algorithm that is a base of all other search possibilities.

Let $U = O \times C$, O is the set of objects and C is the set of characteristics and U is the set of all objects and their characteristics. Let $v(o,c)$ is a function: $v : O \times C \to V$, where V is the set of values of the characteristics.

$p(c,v)$ is a condition for the characteristic c and the value v. In the first version of our search service, there was only one type of condition: $p(c,v) \Leftrightarrow$"objects having value v for characteristic c". Let P be the set of all possible conditions for $c \in C$ and $v \in V$.

Let define the search function $s(p,u)$, where $p \in P$ and $u \in U$, $s : P \times U \to U$. The result is a set $S \subseteq U$.

Let assume that we search on n characteristics.

So, in the first version of our searching service, we used the following algorithm:

$S_1 = s(p_1, U) \to$ time for execution $= t_1 = t$

$S_2 = s(p_2, U) \rightarrow$ time for execution $= t_2 \approx t$

$S_3 = s(p_3, U) \rightarrow$ time for execution $= t_3 \approx t$

……

$S_n = s(p_n, U) \rightarrow$ time for execution $= t_n \approx t$,

where p_n are the conditions for all n characteristic.

The result of our search will be:

$R = S_1 \cap S_2 \cap S_3 ... \cap S_n$ (See Figure 7)

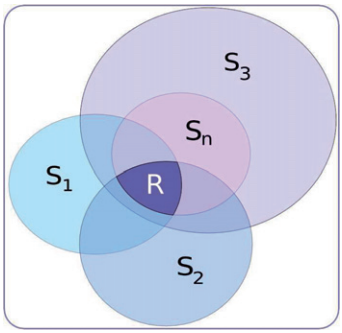


Figure 7: Result set of the search in the first release of the BIDL

If we assume that the time for making one search iteration over the all set of objects and their characteristics U is t, therefore the execution of the whole algorithm will spend $t_{v1} = t_n$ time + the time needed for the intersection of the results in the first release of searching services.

The current version of the searching service had the following changes:

The types of conditions raised to 5:

1. "objects having value $= v$ for characteristic c" – the same as in version 1
2. "objects having value $\neq v$ for characteristic c"
3. "objects having numeric value $\geq, \leq, <, >, or = v$ for characteristic c "

4. “objects having characteristic c”
5. “objects NOT having characteristic c”

The algorithm for the search function changed to (see Figure 8):

$S_1 = s(p_1, U) \rightarrow$ time for execution $= t_1 = t$

$S_2 = s(p_2, S_1) \rightarrow$ time for execution $= t_2 \leq t_1$

$S_3 = s(p_3, S_2) \rightarrow$ time for execution $= t_3 \leq t_2$

……

$S_n = s(p_n, S_{n-1}) \rightarrow$ time for execution $= t_n \leq t_{n-1}$

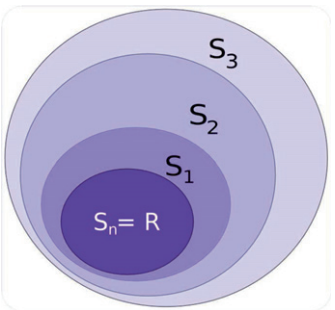


Figure 8: Set of results of the search in the current release of the BIDL

The result R will be equal to S_n, so no intersection will be needed. The time for execution $t_i \leq t_{i-1}$ is because at each iteration the search set $S_i \subseteq S_{i-1}$, therefore the time for processing a search decreases.

In this way, the overall time for execution will be $t_{v2} = \sum_{i=1}^{n} t_i \Rightarrow t_{v2} \leq t_n$ and $t_{v2} < t_{v1}$, t_{v2} is the time needed for results generation in the current release of searching services.

Administrative Services

The *Administrative services* panel mainly provides user data management, data export, tracking services, and analysis services. The user data management covers the activities related to registration, data changes, level set, and tracking activities of the user. The tracking services have two main branches: tracking of MDL objects, tracking of MDL user' activities. The tracking of MDL objects spies on the activities of add, edit, preview, search, delete, selection, export to XML, and group of MDL objects/collections in order to provide a wide range of statistic data (for frequency of service usage, failed requests, *etc.*) for internal usage and generation of inferences about the stable work (stability), the flexibility, and the reliability of the environment. The tracking of MDL user' activities spies user logs, personal data changes, access level changes and user behaviour in the BIDL.

The QlickTech® QlinView® Business Intelligence[4] software is the analysis services provider. It is connected to the BIDL tracking services and objects database by preliminary created data warehouse[5].

The ETL (Extract, Transform, Load)[6] is completely automatic process and is performed by administrator request.

The QlickTech® QlinView® Business Intelligence Software is deployed in order to provide fast, powerful and visual in-memory analysis of the data in the warehouse. It is a data access solution that enables you to analyse and use information from different data sources. It is based on online analytical processing (OLAP), which provides an approach to quickly answer multi-dimensional analytical queries (Codd, Codd, & Salley, 1993).

[4] Business Intelligence is an architecture and a collection of integrated operational as well as decision-support applications and databases that provide easy access to great amount of (business) data.

[5] A data warehouse is a repository of an organization's electronically stored data. Data warehouses are designed to facilitate reporting and analysis (Inmon, 1992).

[6] Extract, transform, and load (ETL) is a process in database usage and especially in data warehousing that involves: extracting data from outside sources, transforming it to fit operational needs (which can include quality levels), and loading it into the end target (database or data warehouse).

The variety of generated statistic information about BIDL data using QlickTech® QlinView® provides a rich extension of the tracking services and the base for profound analysis of extracted data.

The export data from the administrative services panel provides the transfer of information packages (for example, packages with BIDL objects/collections, user profiles, *etc.*) compatible with other systems managing databases. For example, with these services a package with BIDL objects could be transported in a XML-based structure for a new external usage in e-learning (Paneva-Marinova, Pavlova-Draganova, Pavlov, & Sendova, 2008) (Pavlov & Paneva, 2006) (Paneva-Marinova, Pavlova-Draganova, Draganov, Pavlov, & Sendova, 2009) or e-commerce applications.

Chapter 5: Content Analysing and Synthesizing Services in an Iconographical Digital Library

Current research on digital libraries is mostly focused on the generation of large collections of multimedia resources and regular tools for their indexing and retrieval. However, digital libraries should provide more than advanced content maintenance and retrieval services. They should aid the users in their content observation, knowledge acquisition and better satisfying their needs, interests and wishes. This chapter presents an extension of the current DL functionality with content analysing services. The main goal is to reach implicit and hidden data, content, rules and facts, dependences and tendencies, valid for the content in the DL repository, to synthesize and summarize the collected data in order to use it in various investigations and learning. These services also observe the DL tracking services' output and provide different inferences for the frequency of service usage, failed requests, user logs and activities, *etc*., assisting the DL environment maintenance through the generation of inferences about its stability, flexibility, and reliability. This interpretation of DL analysing services tries to push up a new research point, aiming to aid user's work in the DL environment.

Digital libraries "should enable any citizen to access all human knowledge anytime and anywhere, in a friendly, multi-modal, efficient, and effective way, by overcoming barriers of distance, language, and culture and by using multiple Internet-connected devices" (Bertino, et al., 2001). The key for such an environment and its efficiency is the provisioning of strictly designed functionalities, which are powered by the observation of the users' preferences, cognitive goals, and needs in order to find optimal functionality solutions for the end users. Current DL releases mainly provide content management services such as: content creation, i.e., adding (annotating and semantic indexing), storing, editing, previewing, browsing, deleting, grouping, and managing multimedia digital objects (images, text, sound, video), collections and their descriptions; metadata management; simple and extended keyword search, complex

semantic and context-based search, selection and grouping of objects; data export, *etc*. A natural extension of these services could be the DL content analysing, synthesizing and summarizing services, providing content and functionality observation, mining, inference, evaluation and tracking.

Current work in DL content analysis mainly concerns the improvement of the DL content by identifying areas of knowledge that are lacking content and using external information sources to augment the existing knowledge. The DL knowledge management systems provide solutions for acquiring new knowledge by either pulling potential data from external sources or by having the data pushed directly from external content providers. Topic-driven and user-driven focused crawling are the mainly used techniques for finding missing content.

DL Content Analysis

The idea of digital library content analysis appeared in order to answer the question how the content of a digital library can be enhanced to better satisfy users' needs, interests, wishes. Missing content is identified by finding missing content topics in the system's query log or in a pre-defined taxonomy of required knowledge. The collection is then enhanced with new relevant knowledge, which is extracted from external sources that satisfy those missing content topics. Experiments of Carmel's team measured the precision of the system before and after content enhancement (Carmel, Yom-Tov, & Roitman, 2008). The results demonstrate a significant improvement in the system effectiveness as a result of content enhancement and the superiority of the missing content enhancement policy over several other possible policies.

Other solutions are provided by the DL knowledge management systems that acquire new knowledge by either pulling potential data from external sources or by having the data pushed directly from external content providers. Topic-driven and user-driven focused crawling are the mainly used techniques for finding missing content

(However, digital libraries that are based on active crawling methods such as CiteSeer often have missing documents in collections of archived publications, such as ACM and IEEE). The goal of the focused crawler is to selectively seek out pages that are relevant to a pre-defined set of topics. The topics are specified not using keywords, but using exemplary documents. Rather than collecting and indexing all accessible Web documents to be able to answer all possible ad-hoc queries, a focused crawler analyses its crawl boundary to find the links that are likely to be most relevant for the crawl, and avoids irrelevant regions of the Web. The basic concept of a focused crawler (topical crawlers) (De Bra, Houben, Kornatzky, & Post, 1994), is based on a crawling strategy that relevant Web pages contain more relevant links, and these relevant links should be explored first. Initially, the measure of relevancy was based on keywords matching; connectivity-based metrics were later introduced (Cho, Garcia-Molina, & Page, 1998). In (Chakrabarti, Van den Berg, & Dom, 1999) the concept of a focused crawler was formally introduced as a crawler that seeks, acquires, indexes, and maintains pages on a specific set of topics that represent a relatively narrow segment of the Web. This leads to significant savings in hardware and network resources, and helps keep the crawl more up-to-date.

Pant's teams developed a topical crawler (Pant, Tsioutsiouliklis, Johnson, & Giles, 2004). Its crawler follows hyperlinks to automatically retrieve pages from the Web while biasing its search towards topically relevant portions of the Web. A trained classifier provides the crawler with the needed bias. Once a collection of Web pages has been downloaded by the crawler, the system analysed them to find more structured information such as potential Web communities and their descriptions. The analysis process includes both lexical as well as link (graph) based analysis. The final result of the analysis is then shown as an interactive graphical report that describes various clusters (potential communities) found through the crawl, their examples, as well as authorities and hubs within each cluster.

Today, focused crawling techniques have become more important for building specialty and niche (vertical) search engines. While both the sheer volume of the Web

and its highly dynamic content increasingly challenge the task of document collection, digital libraries based on crawling benefit from focused crawlers since they can quickly harvest a high-quality subset of the relevant online documents.

Most of the current focused crawling approaches perform syntactic matching, that is, they retrieve documents that contain particular keywords from the user's query. Unfortunately, this often leads to poor discovery results, because the keywords in the query can be semantically similar but syntactically different, or vice-versa. Moreover, the query matching score is calculated taking into account only the keywords from the user's query. Thus, regardless of the context, the same list of results is returned in response to a particular query. In (Pahal, Chauhan, & Sharma, 2007) it is offered an approach for document discovery building on a comprehensive framework for context-ontology driven focused crawling of Web documents.

Su's team presented an intelligent focused crawler algorithm (Su, et al., 2005) in which they embedded ontology to evaluate the page's relevance to the topic. Compared with other algorithms using domain knowledge, this algorithm can evolve the ontology automatically during crawl process. Considering the instinct characteristics of the ontology, propagation has also been imported to accelerate the evolution of the ontology. This approach is applied in several tasks and provided an empirical evaluation which has shown promising results.

The possible interpretations of the DL content analysis beyond the crawling techniques and solutions. In our work we focused on the search of implicit data/content, context, rules, facts, dependences, tendencies, *etc*., valid for the content in the DL repository, and then we synthesize and summarize the collected data in order to use them in various investigations and training situations. We also analyse the DL tracking services' output in order to provide different inferences for the frequency of service usage, failed requests, user logs and activities, *etc*., aiding the DL environment maintenance through the generation of inferences about its stability, flexibility, and reliability. This interpretation of DL content analysis is not proposed and analysed until

now. We try to push up a new research point for the content analysis, aiding user's work in the DL environment.

Needs of Content Analysis in the Iconographical Art Domain

Analysing iconographical artefacts is an activity performed mostly by art experts, theologians, restoration specialists, and art researchers. It subsumes, inter alia, analysis of the theological meaning of iconographical images, art analysis of the tendencies in iconography, the development in time of characters and scenes, the occurrence and activities in iconographical schools, style similarities between objects, periodizing iconographical tendencies, tracing the iconographical technologies in different time periods, iconographical schools, and authors, technological analysis of pieces of art (researching the base, ground, painting layer, polish, *etc.*), researching the donors' and authors' writings, authenticating the object, researching the objects' origin, current condition, state, restoration traces, overpaintings, *etc.* Simple activities helping the analysis are: building (selecting) a collection of samples having certain characteristics (properties), certain values of the properties, having restrictions/rules for the property values; determining the strength of the chosen object set, the internal order and grouping of the objects, displaying the collection, choice evaluation, *etc*. At present this work is done by hand, which takes much time and effort.

An example of a simple task for iconographical arts critics is to make an art critical analysis of the development in time of the iconographic image of Jesus Christ in the various iconographical schools in Bulgaria. The researchers have to perform the following steps:

- Select a certain number of iconographic objects containing the image of Jesus Christ in a one-figure composition. (Note: The right choice requires selecting iconographic objects with the character or Jesus Christ Pantocrator, or Blessing Christ, or Jesus Christ enthroned, or St. Veronica, *etc*.);
- Arrange the iconographic objects in groups by school of iconography;

- If a school of iconography's group contains objects by an eminent author and founder of the school, place these high on the list. Among the objects designated for art critical analysis there should be at least one by a prominent author/school founder, if available;
- Ensure that the iconographic objects designated for art critical analysis are currently in good condition;
- Ensure that at least one primitive iconographic object and at least one Renaissance iconographic object are included in the iconographic objects designated for art critical analysis;
- In writing the art critical analysis compare the selected iconographic objects by contrasting clothing, gesture/s, the character proportions, object/s, the presence of other character/s and/or symbol/s, backgrounds, other element/s (*e.g.*, clouds, *etc.*) in the iconography of the image of Christ. Look for changes in the iconography of these components, for example, appearance or lack of components (objects, symbols, characters, *etc.*), changes in the background, clothing, *etc.*, in the selected set of samples.

Another example is the sample task for the art technique team. It has to find iconographic artefacts/objects containing the image of Jesus Christ in order to compare their specifics from a technological point of view.

Steps to be performed:

- Find all the iconographic scenes with Jesus Christ;
- Choose one iconographic scene with a Lord's Day (Holy Cross, Nativity, Epiphany, Palm Sunday, Ascension, Pentecost and Transfiguration), with the most samples (iconographic objects), minimum 6;
- Ensure the selected iconographic objects are on solid base (wood, stone and metal, bone, glass);
- Ensure only iconographic techniques (tempera, oil, mixed) are used in the painting of the iconographic objects;

- Ensure the iconographic objects contain gilding;
- Ensure the iconographic objects are arranged by temporal characteristics, for example, century;
- In writing the analysis compare iconographic objects in one or more iconographic techniques and evaluate the quality of their execution. Look for periodisation of the employed iconographic techniques in the selected set of samples. Examine the type and technology of the gilding and the structure of the base.

In our work we try to execute these tasks in a DL environment in order to simplify the specialists' work. These examples of analysis constitute a real case for learning-by-authoring in a scenario for technology-enhanced learning process (Pavlova-Draganova, Paneva-Marinova, & Draganov, 2009) in the frames of the SINUS project. The main goal is to demonstrate creative learning-by-doing through active authoring of specific learning materials on East-Christian iconography by learners, using multimedia and information resources delivered through BIDL (Paneva-Marinnova, Pavlov, Goynov, Pavlova-Draganova, & Draganov, 2010) (Pavlova-Draganova, Paneva-Marinova, Pavlov, & Goynov, 2010). SINUS's learning analysis solutions are oriented to semantic-based grouping of iconographic objects using semantic descriptors, representing an extension of the descriptive scheme of BIDL iconographical art content.

For example, in SINUS project the subtasks of the art critics' analysis show steps (sub-goals) to be executed. These steps are presented as a formula combining one of the "Bloom's Taxonomy" verbs (Bloom, 1956) with a term (concept) from the ontology of the East-Christian iconographical art (Pavlova-Draganova, Paneva, & Draganov, 2007) (Paneva, Pavlova-Draganova, & Draganov, 2007). In the SINUS learning platform the **Student** "will execute" the Bloom's verb action on the concept(s) from the ontology of the East-Christian iconographical art. For example, in step 1 the **Student** *collects* iconographical objects presenting *Iconographical character = Jesus Christ* in a composition type = one-figure. In step 2 the **Student** *classifies* (i.e. arranges

the iconographical objects in groups) iconographical objects by a certain iconographic school. In step 3 the **Student** has *to discover-select-show* iconographical objects by a certain author type, *etc*. Tracking all the sub-goals clearly shows the place of the taxonomy terms of the East-Christian iconographical art ontology needed for the learning analysis.

Analysing and Synthesizing in BIDL

An extension of the BIDL functionality is the analysing, synthesizing and summarizing of content, maintaining content and functionality observation, mining, inference, evaluation and tracking. In BIDL these services are performed through the QlickTech® QlinView® Business Intelligence software. As an analysis services provider, it is connected to the BIDL objects repository and tracking services by a preliminary created data warehouse. The QlickTech® QlinView® Business Intelligence software provides fast, powerful and visual in-memory analysis and synthesis of the data, analytical processing (OLAP), quick answering of multi-dimensional analytical queries, *etc*. The ETL is a completely automatic process and is performed by administrator request.

The variety of generated statistical information about BIDL data extends the available visualization services, enabling the user to analyse the iconography domain as well as the library repository at the most granular level of detail required, providing unparalleled insight into the actual states and data dependencies.

For example, Figure 9 depicts the synthesis of the available icons according to the characters painted, iconographic techniques and base materials used.

This information snapshot could be used for an analytical research of an author's work, for an art analysis of the emphasis, trends, and areas it covers, the priorities in their work. There is an opportunity to know their art in more detail.

There is another type of diagrams, related to tracing the integrity, status and ratio of the content distribution in the repository of the digital library. Such an example is Figure 10 where diagrams for Apostle canonical type are depicted.

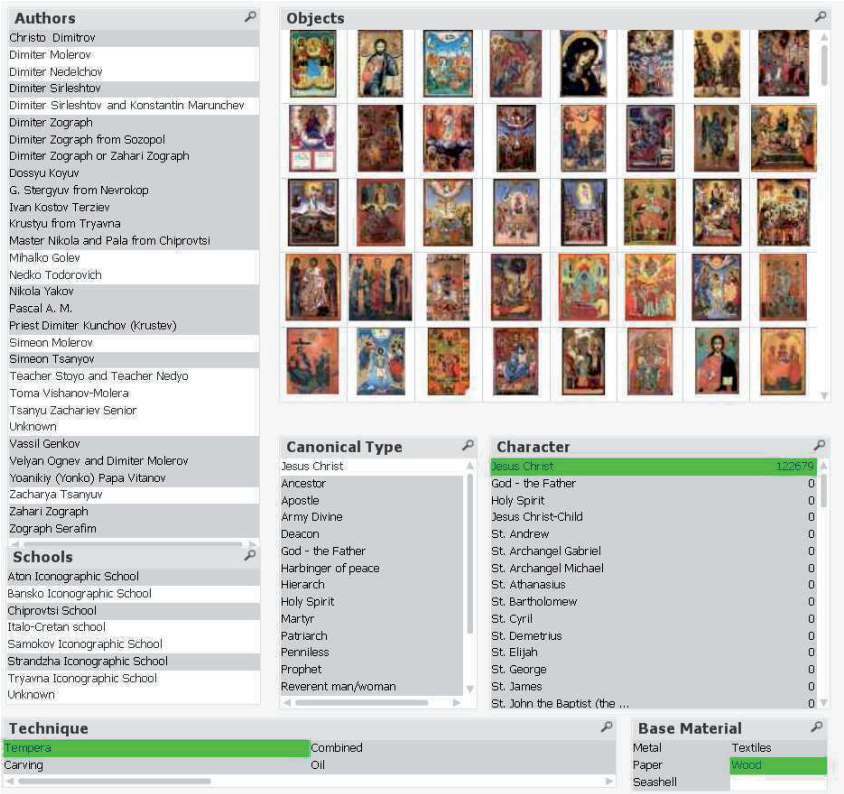


Figure 9: Selection by 3 levels' preview – Technique, Base material, and Character

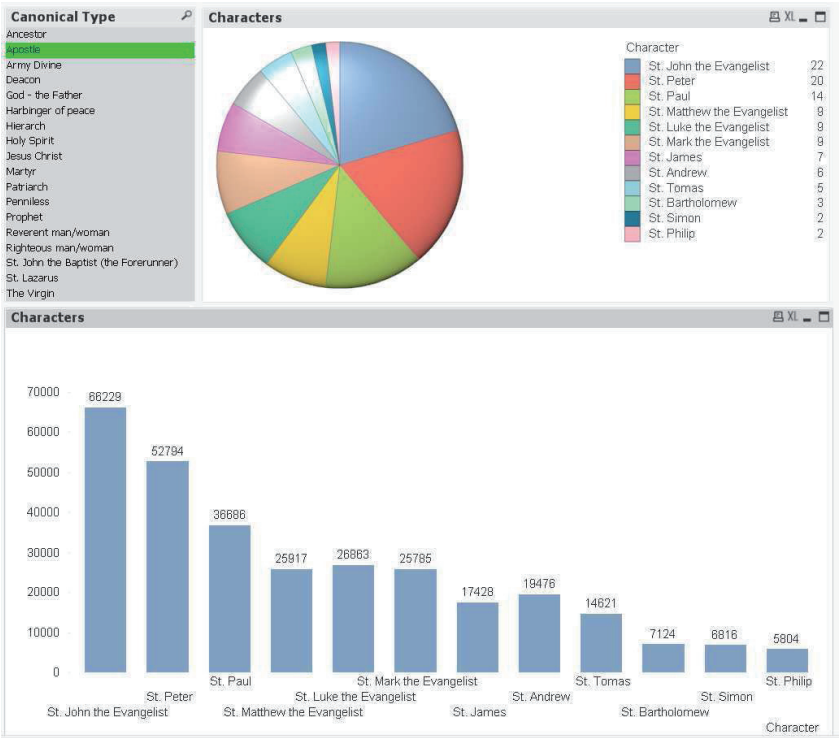


Figure 10: Diagrams of canonical sub-types for Apostle canonical type

Figure 11 depicts the frequency of objects' preview, showing the individual objects.

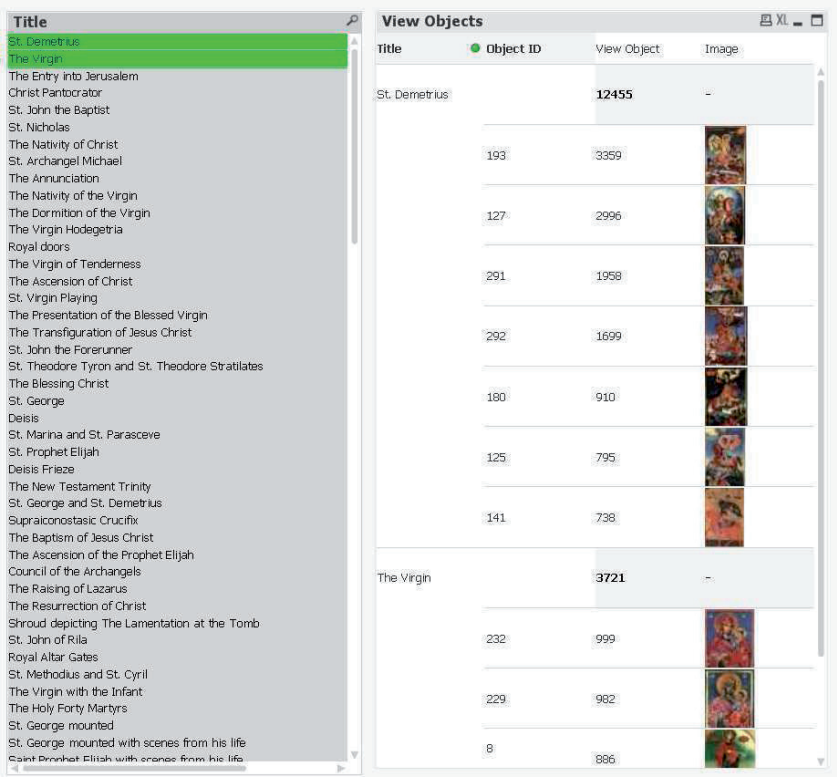


Figure 11: Frequency of objects' preview

This information can be used for making conclusions about people's interest in objects, collections and the library content, in order to further fill the repository of the library.

The implementation of the analysing services in BIDL passes over the building of a special logging service, the design of a fast performing data warehouse and the defining of the ETL process.

The initial BIDL database had the structure depicted in Figure 12.

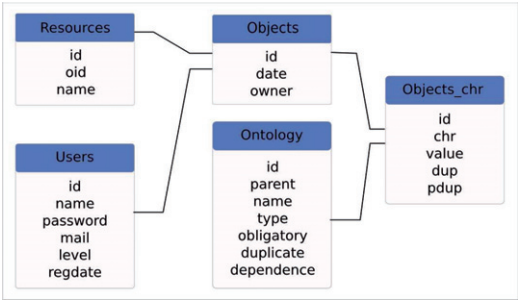


Figure 12: BIDL database structure

There are five main tables used for storing the user data and the content data. For creating the logging service, it was necessary to design another table for that database. The new table has to store all of the user activities, which we are interested in. Therefore, with the new table we have a database like the one depicted in Figure 13.

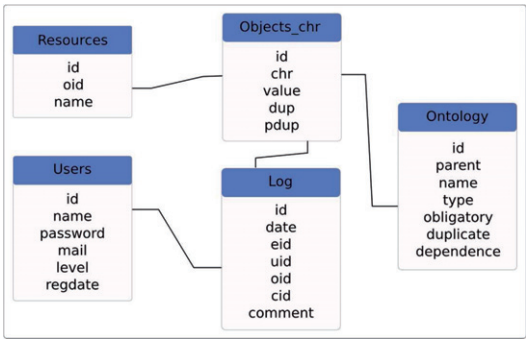


Figure 13: BIDL database structure updated

We have added the log table. Each row of this table represents one user activity. Each activity has:

- A unique identification number;
- A timestamp (the exact time of its execution);
- Event identification (eid – specifies the type of activity carried out by the user);
- User ID – unique user identification number (from the users table);
- Object ID – identifier of the object on which an action is performed (if any)
- Characteristic ID – identifies any concrete object characteristic that takes part in the action which the user has performed;
- Comment – provides additional information about the event.

After analysing our needs for tracking user activities, we decided to track the following types of events (event identification – eid):

- Add file – when a new resource is added;
- Add object – when a new object is created;
- Add user – when an user registers;
- Change password – when an user changes their password;
- Delete file – a file is deleted;
- Delete object – an object is deleted;
- Edit object – an object is edited (modified);
- XML export – XML export of all objects has been performed;
- Group – the group objects service is performed (started, run);
- Login – an user has logged in;
- Login attempt – bad login attempt;
- Logout – user has logged out;
- Remove user – user has been deleted by administrator;
- Search – search action has been executed;
- Change level – user level has been changed;

- View Map – the map service has been executed;
- View Object – view object service;
- View Objects – view a list of objects;
- View Term – view the meaning of a term;
- View Terms – view a list of terms.

These types of events will help us make the various analyses of user behaviour in order to improve the quality of our services according to the DL objects' interests.

Data Warehouse Design

To implement the analysing tool for our DL, we need to design and build a fast performing data warehouse. We choose the snowflake schema for the data warehouse (see Figure 14).

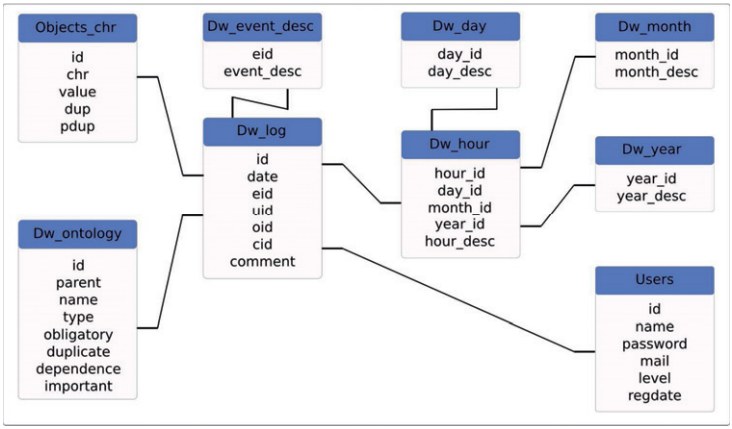


Figure 14: Snowflake schema for the BIDL data warehouse

We use the log table for the fact table of our data warehouse, and the objects, characteristics, and users as dimensional tables. In addition, there are additional tables for the time separation.

We have to note that the table dw_log is different from the table log (and dw_ontology differs from ontology), regardless of the fact that they have the same attributes. The reason is that our data warehouse aims at fast performance, and that is because another process is needed before we start creating our analysis.

The ETL Process (or How to Build and Update our Data Warehouse)

The purpose of this process is to make our data warehouse compatible to our database, so the data transfer from database to data warehouse becomes easy and flawless.

For example, in our case we needed to transfer the timestamp (which contained Year, Month, Day, Hour, Minute, and Second) of the log table to individual entities like: hour, month, year, day for the tables dw_log and dw_hour. We also had to extend the dw_hour table to contain not only values which are connected with one activity, but all values between the times of the first and last activity. When the data warehouse is built and the ETL process is defined, we are ready to start creating our analysis through the QlickTech® QlinView® Business Intelligence software.

Chapter 6: Sharing Services in an Iconographical Digital Library

DLs power will increase significantly if they use mechanisms for ubiquitous sharing of their e-artefacts and they distribute attractive content in the social networks, reflecting community demands and needs. This chapter presents a service for automatic sharing of iconographical artefacts and full collections from the *Virtual encyclopaedia of Bulgarian iconography* multimedia digital library to selected Facebook communities. In this case, the service is used for widely promoting knowledge about East-Christian Iconographical Art and Culture, but I could be used not only for this and not only in this domain.

The Graph API

The Graph API is the core of Facebook Platform, enabling developers to read from and write data into Facebook i.e. the Graph API is used to get data in and out of Facebook's social graph. It's HTTP-based API that is used to query data, post new stories, upload photos and a variety of other tasks that an app might need to do.

The Graph API presents a simple, consistent view of the Facebook social graph, uniformly representing objects in the graph (*e.g.*, people, photos, events, and pages) and the connections between them (*e.g.*, friend relationships, shared content, and photo tags)

The APIs are composed of **nodes** (such as a User, a Photo, a Page, a Comment), **edges** (such as a Page's Photos, or a Photo's Comments), and **fields** (such as the birthday of a User, or the name of a Page).

The Graph API provides many functions over:

Reading - All nodes and edges in the Graph API can be read simply with an HTTP *GET* request to the relevant endpoint.

Choosing Fields - It is possible to choose the fields (or edges) you want returned with the "fields" query parameter. By default, not all the fields in a node or edge are returned when the query is made.

Traversing Paged Results - When you make an API request to a node or edge, you will usually not receive all of the results of that request in a single response. This is because some responses could contain thousands and thousands of objects, and so most responses are paginated by default using *Cursor-based Pagination, Time-based Pagination or Offset-based Pagination*.

Introspection - The Graph API supports introspection of nodes, which enables you to see all of the edges a node has without knowing its type ahead of time.

Publishing - Most nodes in the Graph API have edges that can be published to (such as /{user-id}/feeds or /{album-id}/photos). All Graph API publishing is done simply with an HTTP *POST* request to the relevant edge with any necessary parameters included.

Updating - All Graph API updating is done simply with an HTTP *POST* request to the relevant node with any updated parameters included.

Deleting - You can delete nodes from the graph by issuing HTTP *DELETE* requests to them.

Searching - You can search over many public objects in the social graph with the /search endpoint. All Graph API search queries require an access token included in the request. The type of access token you need depends on the type of executed search:

- Searches across Page and Place objects requires an app access token;
- All other endpoints require a user access token.

Automatic Sharing of Iconographical Content

The following use case diagram (Figure 15) presents the newly defined cases (in orange) which are needed for the implementation of the BIDL Facebook sharing module.

The Facebook BIDL App presentation layer includes the implementation of a BIDL built-in user interface for managing the following use cases:

- Facebook user authentication and authorization, which is required for a Facebook application to access and post content to a specific page, group, wall, *etc.;*
- Facebook Content Publishing module, which will implement the interface between the BIDL and Facebook. The interface includes publishing of posts with links, short description and images for a single BIDL object, and publishing of albums with images, links and short descriptions for BIDL collections and sets of objects;

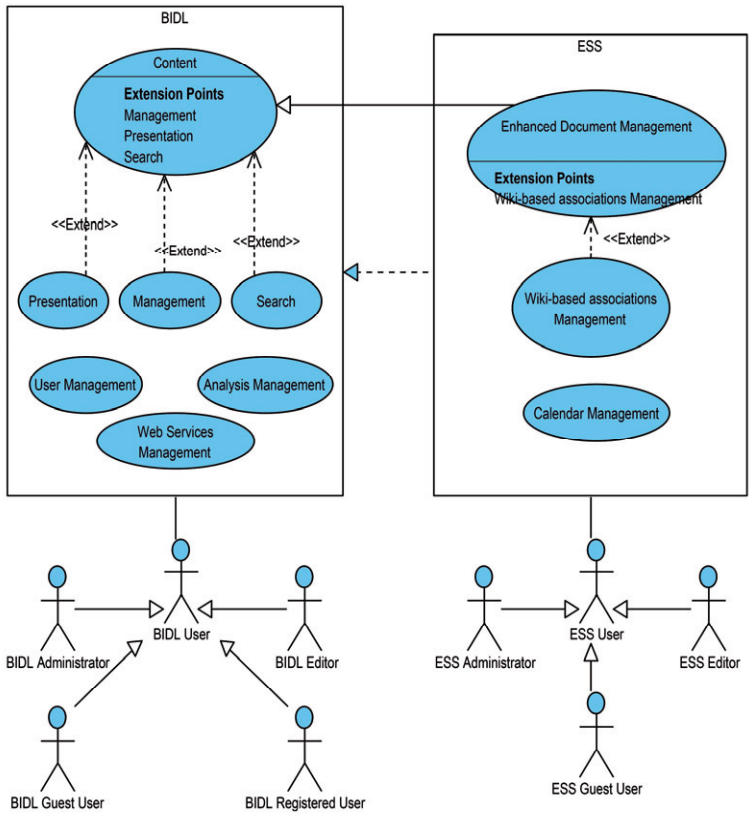


Figure 15: Use case diagram: BIDL Facebook sharing module (Paneva-Marinova, Goynov, & Luchev, 2014)

- Facebook Content Scheduling module, which strongly interoperates with the developed integration (Paneva-Marinova, Pavlov, & Goynov, 2012) between Encyclopaedia Slavica Sanctorum (ESS) (Rangochev, Dimitrova, & Paneva-Marinova, 2012) and BIDL. This way, the automation of publishing content on a specific date is realized. Also, in this case, another benefit of the Facebook Graph API is used – the possibility of the API to create scheduled posts. It is realized by the Facebook feed interface (in the Facebook development

terminology it is and ‘edge’) which includes the following publishing entities (Table 1):

Table 1. Publishing entities

Name	Description
message	The main body of the post, otherwise called the status message. Either link or message must be supplied.
link	The URL of a link to attach to the post. Either link or message must be supplied. Additional fields associated with link are shown below.
actions	The action links attached to the post.
place	Page ID of a location associated with this post.
tags	Comma-separated list of user IDs of people tagged in this post. You cannot specify this field without also specifying a place.
object_attachment	Facebook ID for an existing picture in the person's photo albums to use as the thumbnail image. They must be the owner of the photo, and the photo cannot be part of a message attachment.
targeting	Object that limits the audience for this content. Anyone not in these demographics will not be able to view this content. This will not override any Page-level demographic restrictions that may be in place.
feed_targeting	Object that controls news feed targeting for this content. Anyone in these groups will be more likely to see this content, those not will be less likely, but

Name	Description
	may still see it anyway. Any of the targeting fields shown here can be used, none are required.
published	Whether a story is shown about this newly published object. Default is true which means the story is shown. This field is **not** supported when actions parameter is specified. Unpublished posts can be used in Sponsored Stories.
scheduled_publish_time	Time when this post should go live, this can be any date between ten minutes and six months from the time of the API call.
backdated_time	Specifies a time in the past to back-date this post to.
backdated_time_ granularity	Controls the display of how a backdated post appears. For example, if you pick month posts will be displayed as 2 months ago. instead of an exact date.

The **scheduled_publish_time** and b**ackdated_time** API entities allow the Facebook applications to manage the date and time of publishing an object (post, link, album, *etc.*). This implementation of the API, enables the BIDL application to be flexible and to manage maximum automation of our required purpose.

The screenshots (Figure 16 and Figure 17) present an example of the result of the implemented integration between Facebook and BIDL. The automatically created objects – posts, links and albums are as usual, as if they were manually created. Also, they can be commented, liked, shared in the social set. Thus, the purpose for increasing the popularity of a certain domain can be realized with a great success.

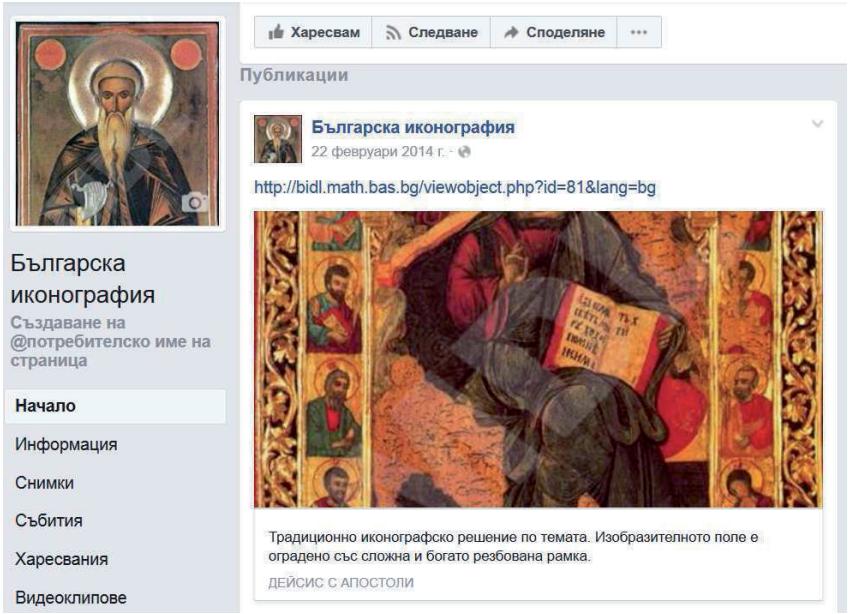


Figure 16: The automatically created BIDL Facebook objects (Paneva-Marinova, Goynov, & Luchev, 2014)

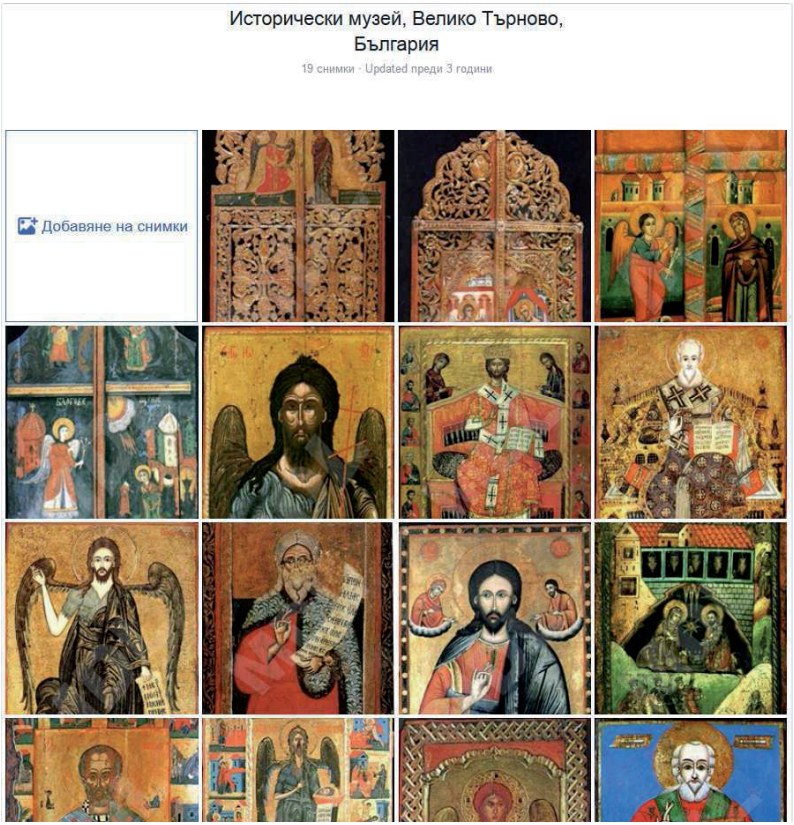


Figure 17: The automatically created BIDL Facebook collections (Paneva-Marinova, Goynov, & Luchev, 2014)

Conclusion

The future work is focused on the implementation of reverse interface – from Facebook to BIDL, aiming to present the likes, shares and comments directly to BIDL and make it possible to create deep analysis, based on the information, gathered from the social set.

The work continues not only with implementation of service for automatic sharing of artefacts and full collections in another digital libraries, but with development of tolls for integrated sharing of information from different libraries, adding to the BIDL data (icons, pictures) the source materials of ESS (canonical and medieval texts) and of Multimedia Library for Bulgarian Traditional Culture and Folklore (folklore and uncanonical records (Pavlov, Bogdanova, Paneva-Marinova, Todorov, & Rangochev, 2011). The results will give complex information to the users of automatically shared objects in social networks.

Chapter 7: Other Classifications of Basic Services in Digital Libraries

The main scopes of this chapter is to make an overview of the basic DL services related to readers, authors, administrators and the interoperability services. A classification and a detailed description are presented.

Readers services cover all related to web user interface navigation web feeds, cross references, Web 2.0 services (tagging, comments, ratings, reviews, bookmarks, share this), statistical reporting, email-alert and online subscriptions. Authors services are considered that they have all readers services and according functionalities, but with difference that authors can submit articles, track citations and *etc*. Services for administrators include all related to system maintenance like the most general tasks as management of users, groups and roles, metadata curation *etc*. Interoperability services are considered to the ways in which digital repositories and libraries work with other systems using common standards and protocols. Sometimes these interfaces are used directly by people (*e.g.* web user interfaces, web search engines or web feeds like RSS feeds) and sometimes they are used by machine-to-machine. The services could be grouped in the common structure, as it is depicted on Figure 18.

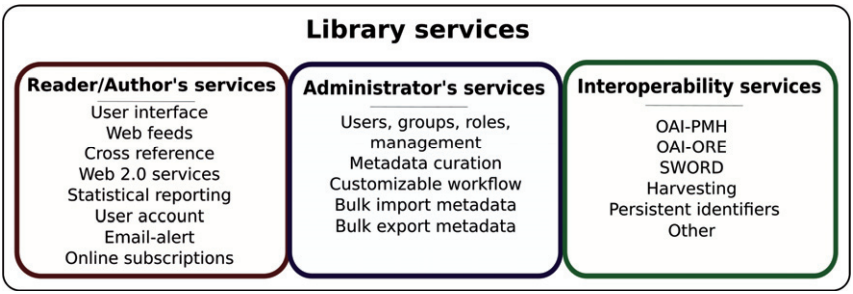


Figure 18: Web 2.0 services

Readers Services (User Interface Services)

The main readers' services (with or without required user registration/account) are:

- User interface (content presentation, content classification scheme, content retrieval, browse, navigation, simple/advanced search);
- Web feeds (RSS, Atom);
- Cross reference (citation linking mechanisms, link resolvers);
- Web 2.0 services (tagging, comments, ratings, reviews, bookmarks, share this, other Web 2.0);
- Statistical reporting (size, diversity, self-counting, count of total items, top downloads, top cited, collection/repository growth over time, *etc*.);
- User account (roles, groups);
- Email-alert;
- Online subscriptions (free access/non-free paid, license model).

Content presentation includes:

- File types of stored items (html, tex, ps, pdf, doc, images, *etc.*);
- Service for online document format conversion – possibility for user to choose in which format to download document;
- Thumbnail (quick preview) - user can view content as a thumbnail (quick preview) in a web browser;
- Option to view full article through web browser without need to download as a file, *etc.*

Content classification scheme haves a role in aiding information retrieval in a network environment, especially for providing browsing structures for subject-based information gateways on the Internet. Advantages of using classification schemes include improved subject browsing facilities, potential multi-lingual access and improved interoperability with other services.

Content retrieval includes actions such as export document in multiple formats and/or extract parts of a document (for example, extraction of only citations, references or figures from a particular article).

Browse and navigation covers browsing by author, subjects, year, title, collections, type of item (article, proceeding, book, *etc.*) and other; content filtering (new, recent, key words, subject, similar, sort results), service for personalized seeking of similar articles/documents, *etc.*

Simple search represents searching by keywords, phrases; predefined search only on metadata field/s (title, abstract, *etc.*).

Advanced search: User can choose different scopes of search. Advanced search also provides any combination of searching at the same time by multiple selected scopes of search linked with conditional logical operators AND, OR, NOT. Advanced search may provide auto completion of search terms; make suggestions with relevant keywords, phrases associated to the user search request.

Web feeds are used to publish frequently updated works such as blog entries, news headlines, *etc.* in a standardized format. An example of web feed format is RSS document (which is called a "web feed", or "channel") includes full or summarized text, plus metadata such as publishing dates and authorship. Web feeds benefit publishers by letting them syndicate content automatically. They benefit readers who want to subscribe to timely updates from favoured websites or to aggregate feeds from many sites into one place. RSS feeds can be read using software called an "RSS reader", "feed reader", or "aggregator", which can be web-based, desktop-based, or mobile-device-based. A standardized XML file format allows the information to be published once and viewed by many different programs. The user subscribes to a feed by entering into the reader the feed's URI or by clicking a feed icon in a web browser that initiates the subscription process. The RSS reader checks the user's subscribed feeds regularly for new work, downloads any updates that it finds, and provides a user interface to monitor and read the feeds.

Cross reference (linking mechanisms, link resolvers): Some examples are Open URL linking, Link resolvers, Electronic resource integration, DOI, CrossRef, Handle.Net.

Web 2.0 services: tagging, comments, ratings, reviews, bookmarks, share this, other.

Statistical reporting: size, diversity, self-counting, count of total items, top downloads, top cited, collection growth over time, *etc*.

User account (roles, groups): Here it should be listed and described any predefined users' roles and groups and the specific services for each of them.

Email-alert: Services related to the notification via e-mail.

Online subscriptions (free access/non-free paid, license model): Terms and conditions. Definitions of offered services, access and use, policy, copyright, *etc*.

Open-Access License models: The more we understand about science and its complexities, the more important it is for scientific data to be shared openly. It's not useful to have ten different labs doing the same research and not sharing their results focusing efforts to expand the use of Creative Commons licenses to scientific and technical research (http://creativecommons.org/science).

License model applied by Public Library of Science (PLoS) is Creative Commons Attribution License (CCAL, http://creativecommons.org/licenses/by/2.5/) to all published works (see the human-readable summary or the full license legal code at CCAL). Under the CCAL, authors retain ownership of the copyright for their article, but authors allow anyone to download, reuse, reprint, modify, distribute, and/or copy articles in PLoS journals, so long as the original authors and source are cited (http://www.plosone.org/static/license.action).

Authors Services

Authors' services cover:

- User interface (content presentation, content classification scheme, content retrieval, browse, navigation, simple/advanced search;
- Web feeds (RSS, Atom);
- Cross reference (citation linking mechanisms, link resolvers);
- Web 2.0 services (tagging, comments, ratings, reviews, bookmarks, share this, other Web 2.0);
- Statistical reporting (size, diversity, self-counting, count of total items, top downloads, top cited, collection/repository growth over time, *etc*.);
- User account (roles, groups);
- Email-alert;
- Online subscriptions (free access/non-free paid, license model);
- Online submissions (license model, copyright, ownership, terms of use, *etc*.).

Administrators Services

Administrators' services include:

- Users, groups, roles management;
- Metadata curation;
- Customizable workflow;
- Bulk import metadata;
- Bulk export metadata.

Users, groups, roles management: Describe existing types of users and roles.

Metadata curation describes existing metadata curation system and how it's implemented. The goal of the curation system is to provide a simple, extensible, way to manage routine content operations on a repository. Some examples are:

- ensure a given set of metadata fields are present in every item, or even that they have particular values;
- profile a collection based on format types - good for identifying format migrations;
- network service to enhance/replace/normalize an item's metadata or content;
- ensure all items are readable and agree with the ingest values.

Customizable workflow: A workflow consists of a sequence of connected steps. It is a depiction of a sequence of operations, declared as work of a person, a group of persons, an organization of staff, or one or more simple or complex mechanisms. Workflow may be seen as any abstraction of real work. For example the workflow may consist of maintaining publications by importing metadata from other sources, and attaching full text where available. This minimizes the amount of manual form-filling needed. The interaction with the repository is limited to selecting which collection (if any) they want their work archived.

Bulk import metadata and *Bulk export metadata:* It is often more efficient to import and export at once large amount of data.

Interoperability Services

The interoperability services and protocols include:

- *Services concerning to Interoperability and Integration* - describe the ways in which repositories work with other systems using common standards and protocols. Sometimes these interfaces are used directly by people (*e.g.* web user interfaces or RSS feeds) and sometimes they are used by machines (*e.g.* OAI-PMH and SWORD). Interfaces used by machines are sometimes referred to as m2m (machine-to-machine) interfaces;
- *Services supporting linking mechanism* - for effective use of distributed electronic resources in libraries. Some examples are Open URL linking, Link resolvers, Electronic resource integration, DOI, CrossRef, Handle.Net. Linking

mechanism makes possible to build global digital libraries services and portals, because it provides unique item identifiers, persistent identifiers are used for citation management, *etc*.;

- *Storage and long term preservation of digital information* – it concerns to using well known standards for metadata, storage data formats, *etc*. with provided support for a long time. Polices according to systems and software management, physical security, data security, data backups, disaster recovery, redundancy of data (multiple data duplication, digital archives, global web portals, providing content aggregation from various sources distributed over the Internet), *etc*.

Chapter 8: Standards for Digitized Cultural Heritage, Saved in Digital Libraries

This chapter discusses several standards, which concern digital cultural content, saved in digital libraries. According to content specifics in (Ivanova, Dobreva, Stanchev, & Totkov, 2012), four types of standards are specified: data structure, data content, data value, and data communication. The authors are also discussing groups of standards, taking into account the application area they served - common standards, standards for resource discovery, specific standards for libraries, archives and museums and other standards, relevant to cultural heritage. In this chapter, we review some standards and their metadata schemes, making possible the key functions in DLs: identification, management, access, use, and presentation of digital CH resources.

Dublin Core

Dublin Core (DC, http://dublincore.org/) is the most popular standard (developers: the Dublin Core Metadata Initiative, 1995). The standard contains in its basic part (dc namespace) only 15 elements: contributor, coverage, creator, date, description, format, identifier, language, publisher, relation, rights, source, subject, title and type. Each is optional and repeatable, and may appear in any order. This simple generic element set is applicable to a variety of digital object types. It is used for the description, access and search of simple textual or image resources. For richer descriptions enabling more refined resource discovery, the Qualified Dublin Core has been developed. It includes additional qualifiers to the basic 15 elements to further refine the meaning of an element. It contains 7 additional groups with 126 metadata elements.

OAI-PMH

Open Archives Initiative Protocol for Metadata Harvesting (OAI-PMH, http://www.openarchives.org) was established in 2002 and represents a protocol developed for harvesting (or collecting) metadata descriptions of records in an archive so that services can be built using metadata from many archives. OAI-PMH provides an application-independent interoperability framework based on metadata harvesting. It is directly connected with Dublin Core and XML. The OAI-PMH is adopted by many digital libraries, institutional repositories, and digital archives.

MARC 21

MARC 21 Format for Bibliographic Data (https://www.loc.gov/marc/) is designed to be a carrier for bibliographic information about printed and manuscript textual materials, computer files, maps, music, continuing resources, visual materials, and mixed materials. The five MARC 21 communication formats, *MARC 21 Format for Bibliographic Data*, *MARC 21 Format for Authority Data*, *MARC 21 Format for Holdings Data*, *MARC 21 Format for Classification Data*, and *MARC 21 Format for Community Information*, are widely used for representation and exchange of data in machine-readable form.

METS

The METS (Metadata Encoding&Transmission Standards, http://www.loc.gov/standards/mets/) schema is a standard for encoding descriptive, administrative, and structural metadata regarding objects within a digital library, expressed using the XML schema language. The standard is being developed as an initiative of the Digital Library Federation in 2007. METS contains 33 XML elements located in a tree-base structure.

CIDOC Conceptual Reference Model

The CIDOC Conceptual Reference Model (CRM, http://cidoc-crm.org/) provides definitions and a formal structure for describing the implicit and explicit concepts and relations used in cultural heritage documentation. The CIDOC CRM is intended to promote a shared understanding of cultural heritage information by providing an extensible semantic framework that any cultural heritage information can be mapped to. CIDOC CRM is a common language for domain experts and implementers to formulate requirements for information systems and to serve as a guide for good practice of conceptual modelling. In this way, it can provide the "semantic glue" between different sources of cultural heritage information, such as those published by museums, libraries and archives. The CIDOC CRM object-oriented model provides 148 hierarchical classes, used for CH documentation.

Europeana Data Model

The Europeana Data Model (EDM, http://pro.europeana.eu/page /edm-documentation) is a theoretical data model that allows data to be presented in different ways according to the practices of the various domains, which contribute data to Europeana[7]. EDM separates the cultural heritage object from its digital representation in order for metadata values to be associated appropriately. EDM is a major improvement on Europeana Semantic Elements, Europeana's first data model. EDM transcends domain-specific metadata standards, yet accommodates the range and richness of community standards such as LIDO[8] for museums, EAD[9] for archives or

[7] Europeana is a large-scale repository and aggregator for different kinds of cultural heritage assets from Europe.

[8] Lightweight Information Describing Objects (LIDO, www.lido-schema.org) is the result of the collaborative effort of international stakeholders in the museum sector, starting in 2008, to create a common solution for contributing cultural heritage content to portals and other repositories of aggregated resources. Being an application of the CIDOC CRM, Museumdat, SPECTRUM, and CDWA Lite, it provides an explicit format to deliver museum's object information in a standardized way.

[9] Encoded Archive Description (EAD) is established by the Society of American Archivists and MARC Standards Office of the Library of Congress in 2002 for a description of archives and collections. The resources in the archives and collections are described vie finding aids.

METS for digital libraries. It facilitates Europeana's participation in the Semantic Web, basing itself on an open, cross-domain, semantic web-based framework. EDM is a more developed data model that brings more meaningful links to Europe's cultural heritage data. This will result in sharing an enriched content, adding to it and thereby generating more content in ways that no single provider could achieve alone. The EDM semantic approach will translate into richer resource discovery and improved display of more complex data.

VRA Core

VRA Core (https://www.loc.gov/standards/vracore/) is a data standard for the description of works of visual culture as well as the images that document them. VRA Core was first developed in 1996. The current version 4.0, released in 2007, is expressed as an XML schema in order to support the interoperability and exchange of VRA Core records. The standard is hosted by the Network Development and MARC Standards Office of the Library of Congress in partnership with the Visual Resources Association. VRA Core contains 13 categories with 119 metadata elements and a blueprint of their hierarchical structuring. VRA Core could be used both as a standalone format, and as an approved extension schema to METS for objects that contain cultural heritage resources.

SPECTRUM

SPECTRUM (http://www.collectionstrust.org.uk/collections-link/_collections-management/spectrum) represents a common understanding of good practice for collections management in UK museums. It was developed in 2007 and contains 481 metadata and 21 detailed procedures for managing the processes that an object goes through during its lifecycle in a museum. Each procedure has been represented as a workflow diagram with five headings (People, Process, Linked procedures, Information and Systems), maintaining an unambiguous content management.

ALTO (Analyzed Layout and Text Object)

The standard was initially developed for the description of text OCR and layout information of pages for digitized material. The goal was to describe the layout and text in a form to be able to reconstruct the original appearance based on the digitized information - similar to the approach of a lossless image saving operation. ALTO (https://www.loc.gov/standards/alto/) is an open XML Schema that details technical metadata for describing the layout and content of physical text resources, such as pages of a book or a newspaper. ALTO is often used in combination with Metadata Encoding and Transmission Standard (METS) for the description of the whole digitized object and creation of references across the ALTO files, *e.g.* reading sequence description.

Chapter 9: Implementations of Digital Libraries for Various Cultural Assets

This chapter presents several IMI—BAS's implementations of the digital library management systems for various cultural assets. The presented environments aim to provide flexible and effective access to the multimedia presentation of the cultural heritage artefacts, maintaining different forms and formats of the digitized information content, complex/heterogeneous digital objects and collections and rich functionality for interaction. The following DL environments and their specifics are described: a) *The Orthodox Icons Collection of the Regional Historical Museum—Burgas*; b) *Encyclopaedia Slavica Sanctorum*; c) *Multimedia Library for Bulgarian Traditional Culture and Folklor*e; d) *BellKnow Multimedia Archive*; e) *Interactive Environment for Digital Preservation and Preservation of Fashion Objects.*

The Orthodox Icons Collection of the Regional Historical Museum—Burgas

In 2014, thanks to project №BG161P003-1.2.02-0022-C0001 "Implementation of new office for transfer of innovation technologies in business organisations of the South-East Region of Republic Bulgaria" with beneficiary Burgas Free University, co-financed by the Operative Programme "Development of the Competitiveness of the Bulgarian Economy" 2007–2013[10], Regional History Museum Burgas (RHM-Burgas) started the implementation of technological innovation associated with the creation of a digital library collection of icons stored in the Historical exposition of the museum (Stewart, et al., 2015). The project financed the transfer of technology solutions for creation, integration and development of multimedia digital libraries with applications in cultural heritage developed in IMI—BAS. The purpose of the transferred technology

[10] Website of the Office for transfer of innovation technologies in business organizations of the South-East Region of Republic Bulgaria: http://www.bfu.bg/bg/organizatsionna-struktura/ofis-za-tehnologichen-transfer

is to provide adequate and comprehensive presentation, documentation, cataloguing and preservation of the museum's iconographic collection. It will provide a user-friendly platform for the presentation of in-formation from the inventory records, which ensures a more effective and stable work process aiming long-term preservation of the information for posterity. Digital Library "Virtual Collection of Icons" developed for RHM-Burgas (http://www.burgasmuseums.bg/bidl/) contains the basic functionality, already presented in the previous chapters, trying to provide solutions satisfying the requirements of the client – RHM-Burgas and the specifics of the target objects (Stewart, et al., 2015).

Encyclopaedia Slavica Sanctorum

Encyclopaedia Slavica Sanctorum is a joint project of University of Sofia "St. Kliment Ohridski" and Institute of Literature, Old Bulgarian Literature section. Its main goal is to build a repertoire of medieval and early modern Bulgarian texts for saints in combination with ethnological data and some visual sources. The repertoire is not limited to Bulgarian, Slavic, or Balkan saints. Rather, the idea is -- through the study of the history of adoption of numerous Christian cults mostly from Byzantium -- to shed additional light on the reception of Byzantine culture, of *Romanitas* perceived as *Christianitas*, in Bulgaria.

In the framework of this project, a large number of diverse source materials is planned to encode, such as mediaeval vitae of saints, homilies about saints and feasts, synaxarion readings, offices, prayers (both apocryphal and canonical), calendars with liturgical directions in various liturgical books (Gospels, Acts and Epistles manuscripts, Typika), present-day interviews about personal experience of believers, Church and social rites and rituals and their perception by the members of the communities, intercultural and inter-confessional relations and exchange in respect to sainthood. All these primary sources will be published in their original language with scholarly notes and some translations into modern Bulgarian.

An advantage for the users of the platform chosen is the multiple access to the data. If interested in a date of the calendar, the users could find all the saints and feasts that are recorded in the sources consulted for this particular date. If interested in a certain saint or feast, the users could find all the information for him/her/it, for different dates on which he/she/it is celebrated and different books (sources) in which it appears.

The main goal of the project is to produce a digital repository which could be used for on-line access to the Bulgarian (or more widely speaking medieval Slavonic) information on saints which could satisfy scholarly and educational needs. Also there would be information which could be of interest to the general public, for instance lectures, multimedia products, exhibitions. The repository, called Encyclopaedia Slavica Sanctorum or Encyclopaedia Slavica Sanctorum Calendar or simply Calendar, is developed using digital libraries and Semantic web technologies (Goynov, Paneva-Marinova, & Dimitrova, 2011). The software implementation is executed by a team from the Institute of Mathematics and Informatics – Bulgarian Academy of Sciences.

Encyclopaedia Slavica Sanctorum Project Specifics

The *differentiae specificae* of the Encyclopaedia Slavica Sanctorum project in comparison with other reference books on cults and saints are:

1. The encyclopaedia includes information only on saints that are identified in medieval and early modern Slavonic sources.
2. The approach towards the sources concerning the cults of saints is not religious and is rather diachronic than synchronic. We are interested not in the beliefs themselves or in the present-day Church canon about holiness but in the formation of the cults and their role in political, cultural, and everyday life of the Bulgarians through the centuries.
3. The focus of our project is not on the Christian calendar in general but on its reception in the Bulgarian cultural and religious life and in Bulgarian sources. Thus we concentrate on the adaptation of Christian cults and beliefs in the Bulgarian

lands, in Bulgarian medieval translational and original texts and practices, and on their influence for formation of certain mentality in the Bulgarian lands.

4. The approach is predominantly philological: the emphasis is on the edition and representation in an e-version of primary sources according to scholarly standards. These sources are mostly texts: vitae, homilies, offices, calendars in medieval and early modern manuscripts (as well as some translations into modern Bulgarian) and ethnological records of interviews. To a lesser degree images will be added to the textual material: their role in the life, beliefs, sensitivities will be focused rather than their iconographic and stylistic features.
5. The e-collection of the texts includes not only original works in Old Bulgarian literary language (known also as Old Church Slavonic) but also numerous translations from Greek into Old Bulgarian. As far as it is possible, the date and place of a given translation will be specified as well as its dissemination in those lands in which was used the Cyrillo-Methodian (Old Bulgarian/Old Church Slavonic) literary language.

It is our understanding that when all the accessible primary sources are put together in a clearly structured ontology with multiple access points it will become possible to analyse – without prejudice and bias – the history of cults and their role in political and social life and even the lives of individuals.

The main concern of the project and its main *differentia specifica* is to publish the texts with the necessary *apparatus criticus* according to scholarly standards in classical studies, palaeoslavistics and ethnology, so that they could serve as a reliable basis for objective scholarly approach. Therefore all possible resources should be used for representation of texts as close as feasible to their originals (without scholarly intervention and manipulation of the sources), on the one hand. On the other, the e-editions should allow for accompanying the text with detailed scholarly notes clearly discernible from the "voices" or the primary sources.

Encyclopaedia Slavica Sanctorum Environment

The Encyclopaedia Slavica Sanctorum (ESS) environment should consist of standard functionalities for a digital library, managing cultural heritage content. As extension in ESS there are also additional domain specific functionalities that must be implemented within the system, providing enhanced document management.

As a framework for ESS we are using the BIDL, mentioned above. This library is produced to be easy modifiable for new domain and application.

The next use case diagram describes the main use cases for the BIDL, extended with the use cases required for the ESS (models are described according to the UML notation).

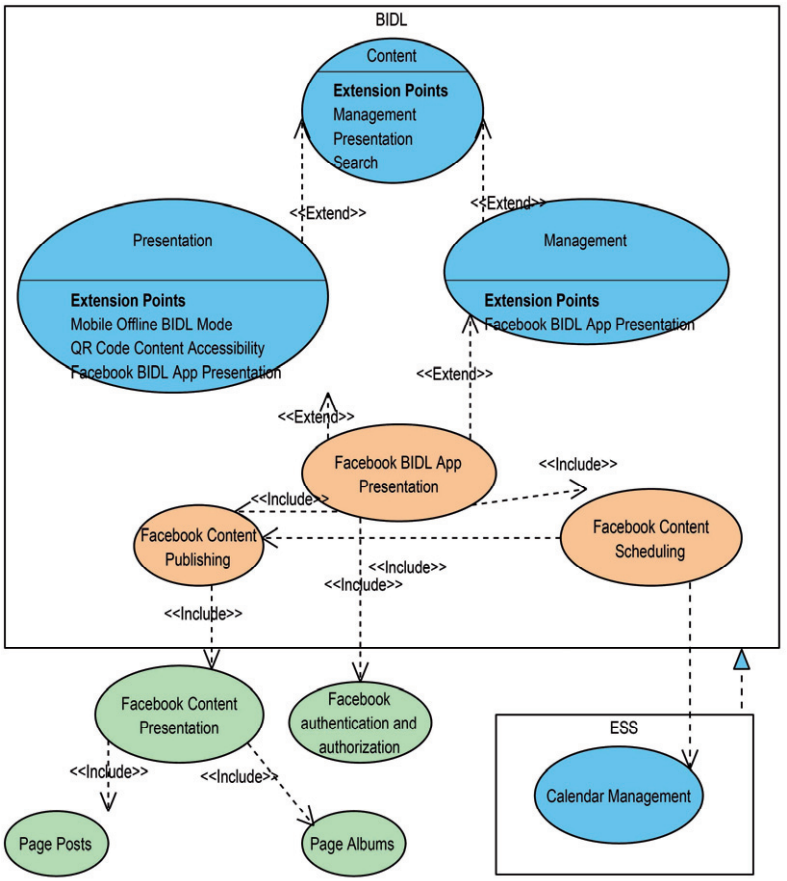


Figure 19: UML Use Case Diagram

The main BIDL use cases are: *Content Presentation*, *Management* and *Search*. The environment also provides *User, Analysis* and *Web Services management*.

The specific ESS use cases are:

- Document management, which should be more powerful, because of the large amount of documents (media files) related to one ESS object;
- Wiki-based associations, which are required for the structured presentation of the ESS objects;

- Calendar management - this functionality is needed because the main ESS object is the Calendar. All other objects - dates and memories (events and saints) are concerned in the hierarchy as secondary objects.

ESS provides functionalities, such as Content Management, Content Presentation, Content Search and Filtering, User Management, Analysis Management (which includes content analysis and user activities analysis and monitoring) and Web Services Management (required for the Integration of the system with other content management systems) (Rangochev, Goynov, & Radoslavova, 2015).

The following diagram (see Figure 20) presents the main entity classes that should be implemented in the ESS.

The *Calendar* class is the primary class. It contains *Dates*. Each date can contain *Calendar Notes* for the day and also objects from the *Commemoration* (sanctoreme) class. The *Commemoration* class is used to generalize the classes *Saint* and *Event*, i.e. the *Commemoration* can be a *Saint* (*St. John of Rila*, for instance) or an *Event* (*e.g. Translation of St. John of Rila's relics to the Rila Monastery*). *Saints* have more specific characteristics than *Events – Type* and *Vita*. All of these classes also have their own descriptive ingredients.

The presented structure represents the backbone of the domain specific ontology used in Encyclopaedia Slavica Sanctorum for semantic content annotation.

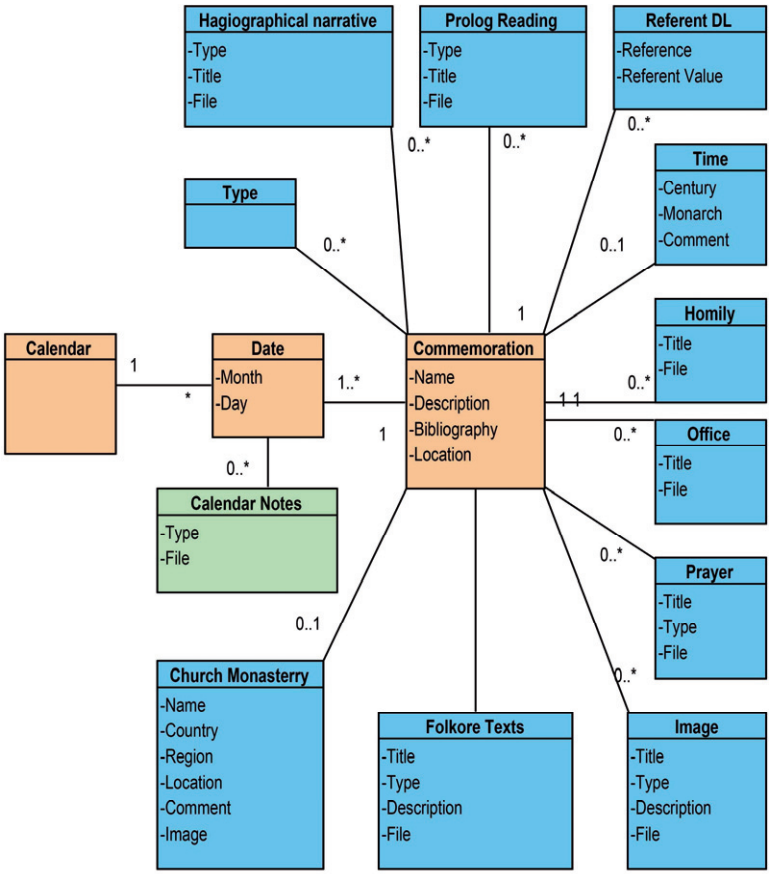


Figure 20: UML Analysis Class Diagram of the main entity classes in the Encyclopaedia Slavica Sanctorum

Encyclopaedia Slavica Sanctorum Calendar is available at: http://www.eslavsanct.net/

Multimedia Library for Bulgarian Traditional Culture and Folklore

Preserving and presenting the national folklore heritage is a long-term commitment of scholars and researchers working in many areas. From centuries, every

generation aims to keep records about work and social life, so that they could be revised and studied by the next generations. For a long time this heritage has been maintained in libraries, museums and research laboratories, where not everyone was able to access this wealth.

In an attempt to answer the need of wider accessibility and popularization of Bulgarian folklore culture, a team from the Institute of Mathematics and Informatics has developed a Bulgarian folklore digital library (BFDL) (Paneva-Marinova, Pavlov, & Rangochev, 2010) within the "Knowledge Technologies for Creation of Digital Presentation and Significant Repositories of Folklore Heritage" national research project (Folknow). The project aims to develop a complete web-based environment for a virtual presentation of the Bulgarian folklore treasure kept in the funds of the Institute for Folklore of the Bulgarian Academy of Sciences.

Folknow Project

The project "Knowledge Technologies for Creation of Digital Presentation and Significant Repositories of Folklore Heritage" makes an fundamental research on contemporary technologies for virtual exposition of intangible cultural heritage. Its aim is to build an experimental release multimedia digital library for Bulgarian folklore objects. The complex structure and the multi-layer characters of the folklore objects require an innovative approach for knowledge representation. The rich-in-content web-presenting of the Bulgarian folklore knowledge defines the usage of modern methods and technologies for developing a digital archive, which will be used not only for preservation and access to the information, but as a tool for scientific research analysis development. The main project's tasks are to create a digital library and information artery with semantic-sensible inferring maintenance in order to present in virtual form the valuable phenomena of the Bulgarian folklore heritage in a comprehensive and easy-to-use way. The realization of the project gives a possibility for wide social applications of the multimedia collections for the purposes of interactive distance learning/self-learning, research activities in the field of Bulgarian traditional culture,

and for cultural tourism and ethno-tourism in Bulgaria (Bogdanova, Pavlov, Todorov, & Mateeva, 2006).

Complexity of the Bulgarian Folklore Domain

The folklore knowledge and therefore the ethnological research have a systemic character (Rangochev, 1997). Since the early period of Bulgarian ethnology until the present day, scholars describe, investigate, and analyse different descriptive schemas for this knowledge. As a rule, scholars study a certain area of knowledge in a particular topos of the Bulgarian ethnical territory and find out an algorithm (where there is a process) or a structural description and afterwards the procedure is repeated in another topos, *etc*. Finally, a summarized algorithm or a structural description is achieved which is – as a matter of fact – the research abstraction (for instance, the "full" description of the "Bulgarian koleduvane" (Christmas rites) is an algorithm which does not coincide with its local variants). All this means that the ethnological studies are hierarchically organized. Leaving the particular topos (a village, for instance), the scholar focuses on bigger entities (such as a region, ethnographical region, or an ethnical territory) and thus he deals with a model of the studied area of ethnological knowledge. A danger in this hierarchical modelling could be the possibility to neglect important systematic links of knowledge (For instance, if we consider some folklore paradigms of kinship, it can turn out that the same person is involved in several systems of kinship: 1. by blood: grandson- son-brother-uncle; 2. by rite: brother-in-law; 3. by profession).

Another problem comes from the specifics of fieldwork investigations. As a rule, the scholar extracts parts of the ethnological knowledge by the means of interview with the informants. Therefore, ethnologists study phenomena which are not person-specific but characterize the community but they use for this purpose the memories and opinions of particular people.

Another important problem is the specifics of the ethnological research: these types of studies are mostly abstract, due to several historical, objective and subjective reasons (technology of recording, ethical, ideological, and scholarly prejudices, *etc*.). The records of samples of Bulgarian folklore which are studied by scholars in practice contain partial information: for instance, songs have been recorded only as texts without notation; or there is no information for the discourse practices conveying the oral narratives; or in many cases the records are made by means of structured interviews and not by inclusive interviews. Therefore, the conclusions of scholars are usually based on partial information (Rangochev, 1997).

All these problems require new flexible methods for representation of knowledge in formal and single structures for securing manners of access and management of this knowledge. In order to formally represent the folklore knowledge the ontology of the Bulgarian folklore was produced.

Ontological Presentation of the Folklore Knowledge

Since one of the targets of the Folknow project is to present the valuable phenomena of the Bulgarian folklore in suitable virtual form using knowledge technologies, we have to observe and specify the experience that has been gained in the last 500 years in the area of traditional folklore i.e. to construct Bulgarian folklore domain ontology.

FolkKnow annotator/indexers using this ontology semantically describes and indexes the raw audiovisual content in order to create and maintain reusable digital objects for the BFDL.

The ontology is also used to realize semantic-based access to concrete digital objects, representing folklore objects, described by their main features, technical data or context. All this information is included within the Folklore Ontology Concept – the root concept for the ontology.

The process of building of the Bulgarian folklore ontology for the Folknow project is necessarily iterative. The first activity is the definition of the scope of the ontology. Scoping has been mainly based on several brainstorming sessions with folklorists and content providers. Having these brainstorming sessions allowed the production of most of the potentially relevant terms.

At this stage, the terms alone represented the concept, thus concealing significant ambiguities and differences of opinion.

A clear issue that arose during these sessions was the difficulty in discovering of definite number of concepts and relations between these concepts. The concepts listed during the brainstorming sessions were grouped in areas of work corresponding naturally arising sub-groups. Most of the important concepts and many terms were identified. The main work of building the ontology was then to produce accurate definitions.

The folklore object is related to two levels of knowledge, enriched with a set of sub-levels of the data classification. All these levels of knowledge or "thematic entities" in the ontology conception are supported by the scientific diagnosis results and the related documentation. The entity "Identification and description" consists of general historical data, identifying aspects such as title, language, archival signature, period, current location of the folklore object, annotation, first level description, second level description, *etc*. The entity "Technical" includes technical information both revealing the technologies used for folklore object capturing and recording, record situation, record type, record place, record date, main participants in the process (record maker and informant), *etc*. A detailed description of the ontology of the Bulgarian folklore is made in (Paneva, Rangochev, & Luchev, 2007) (Luchev, Paneva, & Rangochev, 2008).

To efficiently represent the folklore annotation framework and to integrate all the existing data representations into a standardized data specification, the folklore ontology need to be represented in a format (language) that not enforce semantic constraints on folklore data, but can also facilitate reasoning tasks on folklore data

using semantic query algebra. This motivates the representation of Bulgarian folklore ontological model in Web Ontology Language (OWL). OWL facilitates greater machine interpretability of Web content than that supported by XML, RDF, and RDF Schema by providing additional vocabulary along with a formal semantics. Knowledge captured from folklore data using OWL is classified in a rich hierarchy of concepts and their inter-relationships. OWL is compositional and dynamic, relying on notions of classification, reasoning, consistency, retrieval and querying. We investigated the use of OWL for making Bulgarian folklore ontology using Protégé OWL Plug-in.

Semantics of a Complex Folklore Object

According to the classificatory categories in the Funds of the Institute of folklore of the Bulgarian Academy of Sciences the folklore objects are simple (for example, "song", "food", "magic", *etc.*) and complex (archived objects which cannot be so clearly and unanimously classified: the same units (parts), according to its informational content, could be classified into different Folklore Object Types).

Example of a complex folklore object is CFO A1_146_2-14, an interview containing information of the catholic community in the village of Oresh, Svishtov region, northern Bulgaria (Luchev, Paneva, & Rangochev, 2008). The emphasis in the interview is on the ritual, festival, and everyday life in the village, on the popular beliefs and knowledge. Every one of these folklore object types has several sub-categories. The complex folklore object A1_146_2-14 annotated according to the ontology of the Bulgarian folklore has four subclasses of the Folklore_Object_Type class, in particular: "Ritual", "Faith and Knowledge", "Dreams" and "Food". They have also the following sub-subclasses: "Calendar Rituals", "Family Rituals", "Labour Rituals", and "Rituals for Rain" (Ritual class); "Demonological Personages" (Faith and Knowledge class); "Interpretations" (Dreams class); "Ritual" (Food class). On the next level, this complex folklore object is semantically represented by "Annunciation", "Easter", "Wedding rites", "Funeral rites", "Working Bee", "Spinning Bee", and "Other practices" in Ritual

sub-subclass; further it is represented by “Wood-nymphs” in Faith and Knowledge sub-subclass, *etc.*

BFDL Functionality

The key for the current release of BFDL is the efficiency and the provision of strictly designed functionalities. In BFDL we also follow the requirements of experts in the area of Bulgarian folklore and the accepted functional specification for a digital library (presented in the previous chapters). Following them the basic BFDL functional modules are:

- A module for adding and editing folklore objects. The library expects as an input two types of objects: simple folklore objects and complex folklore objects;
- A module for viewing the content of folklore objects (according to their base type and rubric to which they belong or by different descriptive characteristics);
- A module for searching by: signature and archive number; keywords of the following categories: name, language, annotation, type of the folklore object/rubric; file type; record information (simultaneously or one by one): by situation, by reporter name, by recorder name, by record date and by recording location; extended search – it provides the option for searching through all the object characteristics;
- A module for managing the user data;
- A module for monitoring the user’s actions, which keeps track of the following: a) Actions related to working with the system: registration, logging in the system, unsuccessful log-in attempts, logging out, changing of the user password, e-mail address change, *etc.*; b) Actions related to the object manipulation: adding an object, editing an object, deleting an object, adding a file, deleting a file; c) Actions related to the content viewing: review of objects by their characteristics, view of a single object, searching for objects by

characteristics; d) Other administrative actions: changing the user's level, deleting a user, generation of an XML copy of the data in the system;

- A module for file format conversion;
- A module for generation of XML copies of the objects in the system.

The presented BFDL functionality aims to serve a wide range of users – specialist and non-specialist. The group of specialists is composed by scientists who study Bulgarian folklore professionally and search for specialized information on the observed folklore objects (Bogdanova, Todorov, & Noev, 2010). The group of non-specialists has interests and wants only to learn more about the classical Bulgarian folklore objects. The BFDL system supports several users' levels: administrators, folklore content editors, specialist viewers and non-specialists viewers. Their individual characteristics, needs, interests, motivation, and preferences are discussed in (Pavlov & Paneva, 2006).

Bulgarian folklore digital library is available at: http://folknow.cc.bas.bg/

BellKnow Multimedia Archive

The BellKnow multimedia archive (Bogdanova, Todorov, & Noev, 2011) (Noev, Organization and security of the audio and video archive for unique Bulgarian bells, 2010) (Noev, 2015) (Márkus, et al., 2016) is a multimedia digital environment (library), saving selected valuable bells from Bulgarian churches and monasteries. The archive was developed by a IMI—BAS team within the framework of the project "Research and Identification of Valuable Bells of the Historic and Culture Heritage of Bulgaria and Development of Audio and Video Archive with Advanced Technologies" (BELL) (Noev, 2015). The aim of the project was to study and identify several dozens of the most valuable Bulgarian bells, as well as to develop an audio archive (using advanced technologies) for analysis, reservation and audio data protection. The archive contains:

- The main bells' characteristics: design, form, type, geometric size, decorative and artistic scheme, weight, material, state, characteristics of chime, data about the producer and owner of the bell, estimation of its historical value;
- Digital photos and video recordings of the bells while being tolled;
- The frequency spectrum of the bells during a stroke;
- The bells' frequency spectrum after transitive process;
- Charts representing the sound fade by time, sound stream, sound pressure and other acoustic characteristics.

There are over 3 000 digital resources in archive (photos, video clips, audio recordings, diagrams *etc.*). The first investigations and artefacts are described in (Bogdanova, Todorov, & Noev, 2011) (Noev, 2010) (Luchev, 2006).

Organization of the BELL archive: Tree file structure; Digital files format, parameters, coding; Specific signature for file name; Additional META textual data for indexing of media files: Title (name of subject); Creator (name of digitalizer); Description (additional data); Date (date of creation); Type (type of media); Format (file format, codec and parameters); Identifier (geographic coordinates); Rights (owner of property rights).

The functionality embedded is based on ontology-based knowledge of the bell object and includes the basic activities such as creation, presentation, search and grouping of objects and information content. Glossary of terms in the specific subject area is added. It is overlapping ontological substructure and using its semantic annotations. Functionality modules are built for: optimization and automation of inputting digital resources, their metadata and semantic descriptions; optimization of search in metadata content and semantic descriptions of digital resources; comparison of the digital media resources - collate records of different types (audio, video and photo) of groups of bell objects; presentation of digital resources and objects with their semantic and meta descriptions.

Based on knowledge for each bell, a passport is prepared (Trifonov, Dimokov, & Bogdanova, 2007). This passport is used to document the future of all existing bells in Bulgaria. Passports are summaries of all the information gathered about an object. This includes photographs, historical reference, technical data, charts and research done in the electronic version of the passport - embedded multimedia files with recorded audio and video clips.

Interactive Environment for Digital Preservation and Preservation of Fashion Objects

Undoubtedly, the significant values of the fashion domain have to be made available in the global information medium. Its virtual presentation has to be executed through the best tools and techniques in order to continue to write traces in the history of the world arts. This part presents the project *Multimedia digital library for fashion objects* (MDLFO) and the developers' effort to build an applicable environment for fashion exhibitions.

As an important part of contemporary shared European cultural heritage the fashion takes its unique place in the digital world. The fashion is increasingly recognized as a valuable research object not only in arts, sociology and humanities studies, but also in IT for performing arts and entertainment. Since the beginning of the XX century some of the most important public and private cultural institutions and museums of applied arts in Europe have begun collecting and preserving garments, accessories, catalogues, fashion magazines and other documents and materials related to fashion (Fashion, n.d.). This led to a growing number of impressive and unique collections that are not currently accessible to the public, but through new technological solutions are about their digital Renaissance. Moreover, this valuable cultural heritage could be enriched with the production of young dress designers of the high schools and academies of arts. Following this European initiatives for digitization

and digital presentation of the fashion industry (*viz.* mainly Europeana Fashion, www.europeanafashion.eu)

The MDLFO is an Internet-based digital library - a place where fashion objects of different kinds (sketches, closed models, fashion shows, clothe details, accessories, *etc.*) and origins (students' work, professional dress designers lines, *etc.*) were presented in order to be widely accessible to both dress designers (*incl.* students, learning fashion arts and their mentors) and the wide audience. The library pretend to become a completely interactive multimedia solution that will provide services for documentation, access and usage of a practically unlimited number of fashion objects and knowledge. Moreover, MDLFO can be used as a source of large amounts of information resources for both traditional and e-learning. It will maintain encyclopaedic presentation of the Bulgarian fashion, its traditions and significant achievements. MDLFO also aims to provide services for creative e-performances and will stimulate users' creative thinking and innovative visions by gaming activities.

Semantics of the Fashion Object

The specificity and complexity of fashion objects requires a thorough investigation of the domain so that it can be fully structured and described (Fashion, n.d.). The following parameters must be considered when analysing a type of a garment (Paneva-Marinova, Pavlova, Sapundjiev, & Bogdanova, 2014):

- Year, season and name of the object/collection;
- Size of the garment;
- Material of the garment, parameters of the material: density, elasticity, elongation in X and Y, curves, cutting, *etc.*; variety of types of materials, fabrics: cotton, linen, silk, wool, leather (natural, imitation), synthetic materials, *etc.*, patterns, colour, *etc.*
- Type of the garment /skirt, blouse, trousers, dress/;
- Intended wearers of the collection: women, men, children;

- Occasion for which the garment is designed: casual, evening, sport.

The creation of the fashion object goes through the following stages:

- Fashion sketch or drawing of the model;
- Cutting out a pattern of a certain size;
- Sewing a sample;
- Final selection of the materials and accessories which will be used for making the end product (fashion item), depending on other factors—the author's view, special requirements for the collection, *etc.*;
- Creating the final product (the so-called 'fashion object'), which is ready to be part of an individual or co-authored collection, to have an independent significance (possibly as an individual model or part of it) or to be an individually tailored object following a theme, genre, materials and accessories used, fashion trends, authorship, school, *etc.*

Also of significance is the purpose of the fashion objects—uniquely tailored or ready-made clothing, evening/formal wear, casual, sports, scenographic costumes, festive wear, work wear, uniforms, underwear, *etc.*, as well as the methods of production—by hand, by machine, or mixed.

The ultimate vision of the fashion object or model is demonstrated in a variety of ways: through a photo session, a fashion show, live demonstrations, video clips, advertising, *etc.*, shown in specialised publications and media.

Moreover, the interpretations of the fashion knowledge are not considered isolated from the standards and specifications in the field of fashion representation because the goal is to maximise the reusability and portability of its description.

New information and multimedia technologies that have been developed during the past couple of years introduced new methods of creation, preservation, maintenance and distribution of the huge amounts of collected material. For example, the process of creating a model object, model, collection, *etc.*, is greatly facilitated by advanced IT tools such as OptiTex (CAD/CAM system), Runway 3D, *etc.*

Following the specifics of the fashion objects a special data model of the Interactive Environment for Fashion Objects (IEFO) is created (see Figure 21). It presents the main data objects, their descriptors, interactions and relations. For example, the central data object is *Model* related with all other.

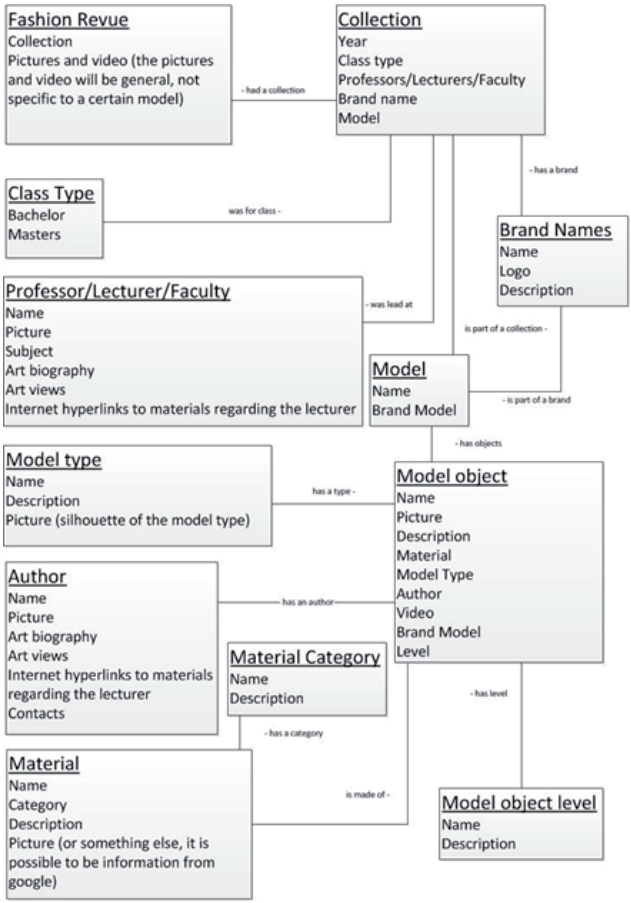


Figure 21: Data model of the Interactive Environment for Fashion Objects (Pavlova-Draganova, Luchev, & Goynov, 2012)

The data model above depicts the developed database solution (see Figure 22).

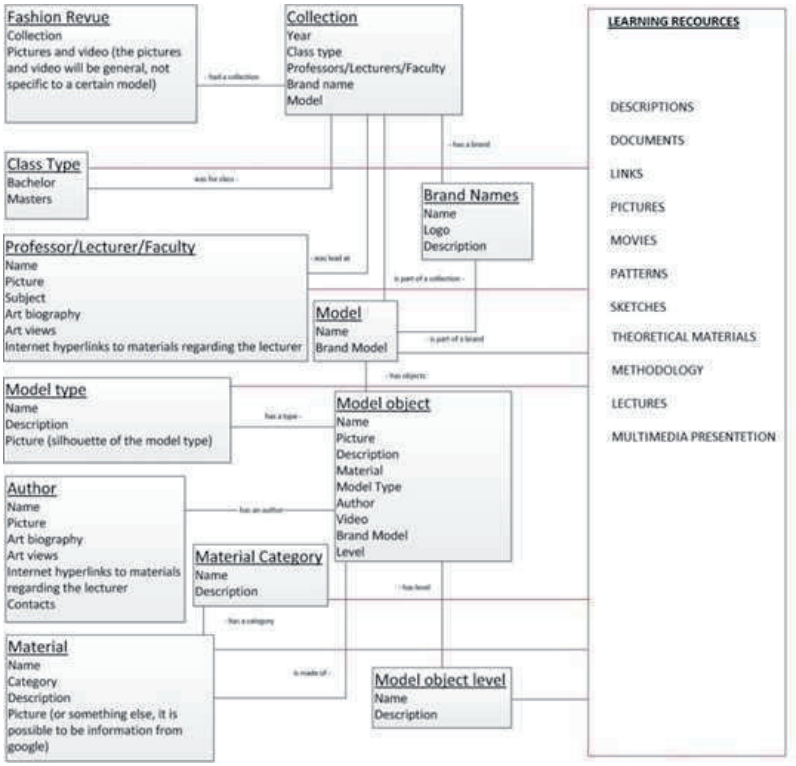


Figure 22: Data model of the Interactive Environment for Fashion Objects connected with digital data repository (Pavlova-Draganova, Luchev, & Goynov, 2012)

IEFO Functional Specification

Following solutions and directions, already mentioned in this chapter, the interactive environment for fashion objects includes basic functionality and services for content creation, content presentation, content search, administrative services, and other services, mainly related to better fashion content observation (*incl.* learning) (Sapundjiev & Luchev, 2015). The environment serves the following groups of users:

Guests, Registered guests, Authors/Students, Professors/Teachers, Administrators. These roles are based on the way of using the environment *incl.* allowed access, rights, obligations, functionality usage, *etc.*

The main part of the content creation process is the annotation and semantic indexing of digital objects (Luchev, Paneva-Marinova, Pavlova-Draganova, & Pavlov, 2013) (Pavlova-Draganova, Luchev, & Goynov, 2012), in order to add them to the IEFO repositories. The metadata entering in the IEFO will be implemented through different automated annotation and indexing services. An annotation template is developed for the description of fashion objects more completely and easy and fast metadata entering. As a part of the content creation panel is included a terminology dictionary (After saving a new fashion object, a special machine traces for the appearance of dictionary terms in the object data. If some terms are available the machine adds links to their explanations. In the case of entering a new dictionary term, its presence in the available objects is discovered automatically and a link is added).

During the development of the content presentation services a profound analysis was made of content selection and preview possibilities in order to satisfy the user's expectations. First we had to determine the preview possibilities of a separate fashion object and its components and after that the preview of grouped objects. The visualization of the rich semantic description of the separate fashion object is determined through hidden parts appearing in a new window after link selection. For example, this possibility is used for long author's biography, dictionary terms, *etc.* Parts of the descriptive data field are also hidden, but their values are available for searching in special forms. The content presentation services includes also object grouping services. The main values of IEFO data model are selected as the object grouping criteria. Using grouping options the guest users (registered or no):

- Can see separately a list of all designers (authors), and selecting one of them he can see additional biographic information and the collections of their work;

- Can see separately a list of fashion object type, and selecting one of the type he can see all fashion models of this type, link to collection of every model and brand name;
- Can see a separately a list of all created brand names, and selecting one of them he can see all models with this brand and all fashion revues of the brand.

Every registered guest can create his private collection of selected objects after search activity. Rich search possibilities are available in order to assist collection creation. The registered guest can write the collection's title and short description. He can also select its status: private or shared with other users.

After building up the main functionality of *IEFO,* it was discovered that there is potential for an entirely direct connection between the *practical part* which is widely used in IEFO from the birth of the idea to its realization into a fashion object, collection and a fashion show and the *theoretical preparation* necessary for this entire cycle. Thus, the idea for creating an electronic storage for learning resources emerged. For this purpose, two steps are performed:

1. Creation of an electronic storage (LEARNING RESOURCES, LR);
2. Establishing connections between LR and IEFO.

The electronic storage is built and organized to serve different kinds of electronic resources and content (i.e. hypertext pages, tasks, video clips, *etc.*). The storage implements technologies, methods and tools for automatic maintenance of digital storages *incl.* generating, updating of virtual catalogues, organization of searching by content, remedying of discrepancies, *etc.* LR has the capability of working independently as a system for storage of learning materials with a centralized access from all other systems for the purpose of ensuring of a unified electronic archive with digital learning materials with the following functionality:

- Centralized access to the learning materials for each professor. The professor has at their disposal a personal digital library to which they provide a partial of

full access to the students (the authors of fashion objects) from each separate study course;

- Capability of storing files/resources, search and extraction of information back from it;
- Indexation of the digitalized documents (manual, automatic);
- Sorting and processing of digitalized documents and creation of a database of digital photographs;
- Processing of new documents, adding and uploading to the electronic storage;
- Capability for each professor to share partially or fully the learning content with other professors;
- Building of an Internet portal for controlled access to the virtual library;
- Building of a virtual archive containing the academic articles and publications of the professors, with profiles of each professor.

The storage maintains the LOM and Dublin Core standards for metadata.

Conclusion

Europe's cultural, historical and scientific knowledge resources are a unique public asset forming the collective and evolving memory of our diverse societies. Resource discovery, accessibility, usability, interoperability, authenticity, quality and trust by all users of the Information Society are essential requirements for the delivery of digital cultural information and services.

European libraries, archives and museums contain a wealth of information, representing the richness of Europe's history, its cultural diversity and its scientific achievements. The degree of access to this information determines how far people can experience their cultural heritage and benefit from it in their work or studies. By digitising their collections and making them available online, libraries, archives and museums can reach out to the citizens and make it easier for them to access material from the past. The online presence of this material from different cultures and in different languages will make it easier for citizens to appreciate their own culture heritage as well as the heritage of other European countries, and use it for study, work or leisure (MINERVAEUROPE, n.d.).

New ICT technological solutions provides opportunities for:

- Improved access and easy content navigation; adapted display specialized content search, grouping, sorting, intelligent curation of digital cultural, historical and artistic objects;
- Selection and recommendation of information;
- Context-dependent use of digital resources;
- Analysis, understanding and interpretation of the content, *etc.*

Different tools and services for create, access, exploit, preserve and reuse various forms of cultural assets, and to model, analyse and visualize them in digital cultural ecosystems are the backbone of this analytical study. Several solutions for content management in were presented. The next step is to preview the extension of this basic functionality – the advanced services for personalized observation and

improved users experience in digital cultural ecosystems, mobile access, interoperability between different ingredients in the digital cultural ecosystem, technology-enhanced learning applications, serious games, gamifications, *etc.*

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References

ArchAIDE. (2016). *Archaeological Automatic Interpretation and Documentation of cEramics, project web page*. Retrieved March 20, 2017, from http://www.archaide.eu/

ARCHES. (2016). *Accessible Resources for Cultural Heritage EcoSystems, project web page*. Retrieved March 20, 2017, from http://arches-project.eu/

Bertino, E., Casarosa, V., Crane, G., Croft, B., Del Bimbo, A., Fellner, D., . . . Fox, E. (2001). *Digital libraries: The future directions for European research programme. Brainstorming report.*

Bloom, B. S. (1956). *Taxonomy of educational objectives: The classification of educational goals, Book 1. Cognitive domain.* New York, NY: Longman.

Bogdanova, G., Pavlov, R., Todorov, G., & Mateeva, V. (2006). Technologies for creation of digital presentation and significant repositories of folklore heritage. *Advances in Bulgarian Science Knowledge, 3*, 7-15.

Bogdanova, G., Todorov, T., & Noev, N. (2010). Digitalization and security of "Bulgarian Folklore Heritage" archive. *CompSysTech, ACM International Conference Proceeding Series (ICPS)*, *471*, pp. 335-340.

Bogdanova, G., Todorov, T., & Noev, N. (2011). Semantic model of digital resources of Bulgarian bells. *Mathematica Balkanica, 25*, 483-490.

Bontchev, B., Paneva-Marinova, D., & Draganov, L. (2016). Educational video games for Bulgarian Orthodox iconography. In L. G. Chova, A. L. Martínez, & I. C. Torres (Ed.), *ICERI2016 Proceedings 9th Annual International Conference of Education, Research and Innovation* (pp. 1679-1688). Seville, Spain: IATED Academy. doi:10.21125/iceri.2016.1374

Bosilkov, S. (1989). *Arbanasi.* Sofia, Bulgaria: Sviat.

Carmel, D., Yom-Tov, E., & Roitman, H. (2008). Enhancing digital libraries using missing content analysis. *Joint Conference on Digital Libraries (JCDL)*, (pp. 1-10). Pittsburgh, PA, USA.

Chakrabarti, S., Van den Berg, M., & Dom, B. (1999). Focused crawling: A new approach to topic-specific web resource discovery. *Computer Networks, 31*(11–16), 1623–1640.

Cho, J., Garcia-Molina, H., & Page, L. (1998). Efficient crawling through URL ordering. *Proceedings of the 7th World Wide Web Conference*, (pp. 161-172). Brisbane, Australia.

Codd, E., Codd, S., & Salley, C. (1993). *Providing OLAP to user-analysts:*. Retrieved April 27, 2017, from An IT Mandate: http://www.minet.uni-jena.de/dbis/lehre/ss2005/sem_dwh/lit/Cod93.pdf

CROSSCULT. (2016). *Empowering reuse of digital cultural heritage in context-aware crosscuts of European history, project web site*. Retrieved March 20, 2017, from http://www.crosscult.eu/

CultEcoSys-Project. (2017). *Concepts and models for innovation ecosystems of digital cultural assets, No. DN02/06/15.12.2016 (project web page)*. Retrieved March 20, 2017, from http://cultecosys.math.bas.bg

De Bra, P., Houben, G., Kornatzky, Y., & Post, R. (1994). Information retrieval in distributed hypertexts. *Proceedings of the 4th RIAO (Computer-Assisted Information Retrieval) Conference*, (pp. 481-491).

Draganov, L., Paneva-Marinova, D., Pavlova, L., Luchev, D., Márkus, Z., Szántó, G., & Szkaliczki, T. (2015). Technology-enhanced learning for cultural heritage. In R. Pavlov, & P. Stanchev (Ed.), *Proceedings of the 5th International Conference on Digital Presentation and Preservation of Cultural and Scientific Heritage. 5*, pp. 293-301. Veliko Tarnovo, Bulgaria: Institute of Mathematics and Informatics - BAS. Retrieved March 25, 2017, from http://dipp.math.bas.bg

Fashion, E. (n.d.). *Putting Europe's fashion heritage online*. Retrieved March 20, 2017, from http://www.europeanafashion.eu/download/press-releases/Europeana-Fashion-Press-Release-EN.pdf

Goynov, M., Paneva-Marinova, D., & Dimitrova, M. (2011). Online access to the Encyclopaedia Slavica Sanctorum. In R. Pavlov, & P. Stanchev (Ed.), *Proceedings of the First International Conference "Digital Preservation and Presentation of Cultural and Scientific Heritage*, (pp. 99 – 110). Veliko Tarnovo, Bulgaria. Retrieved April 20, 2017, from http://dipp.math.bas.bg

I-Media-Cities. (2016). *Innovative e-environment for Research on Cities and the Media, project web page*. Retrieved March 20, 2017, from https://imediacities.eu/

Inmon, W. (1992). *Building the data warehouse.* New York, NY, USA: John Wiley & Sons, Inc.

Ivanova, K., Dobreva, M., Stanchev, P., & Totkov, G. (2012). *Access to digital cultural heritage: Innovative applications of automated metadata generation.* Plovdiv, Bulgaria: Plovdiv University Publishing House.

Luchev, D. (2006). Experimental digital library - Bulgarian ethnographic treasury. *International Conference "Modern (e-) Learning"* (pp. 106-111). Varna, Bulgaria: FOI-Commerce.

Luchev, D., Paneva, D., & Rangochev, K. (2008). Use of knowledge technologies for presentation of Bulgarian folklore herigage semantics. *International Journal „Information Technologies and Knowledge", 2*(4), 307-313.

Luchev, D., Paneva-Marinova, D., Pavlov, R., Kaposi, G., Markus, Z., Szanto, G., . . . Veres, M. (2016). Game-based learning of Bulgarian iconographical art on smart phone application. *Proceedings of the International Conference on e-Learning* (pp. 195-200). Bratislava, Slovakia: University of Ruse, Bulgaria. Retrieved March 20, 2017, from http://elearning-conf.eu/docs/cp16/paper-30.pdf

Luchev, D., Paneva-Marinova, D., Pavlova-Draganova, L., & Pavlov, R. (2013). New digital fashion world. *CompSysTech'13 Proceedings of the 14th International Conference on Computer Systems and Technologies. 767*, pp. 270-275. ACM Inc.

Márkus, Z., Kaposi, G., Veres, M., Szkaliczki, T., Luchev, D., & Paneva-Marinova, D. (2016). BOOK@HAND bells: Mobile presentation of the valuable bells of the historic and culture heritage of Bulgaria. In R. Pavlov, & P. Stanchev (Ed.), *Proceedings of the Sixth International Conference on Digital Presentation and Preservation of Cultural and Scientific Heritage* (pp. 73-80). Veliko Tarnovo, Bulgaria: Institute of Mathematics and Informatics, BAS. Retrieved March 20, 2017, from http://dipp.math.bas.bg

Matakieva-Lilkova, T. (1994). *Bulgarian icon.* Sofia, Bulgaria: Balkan Press.

Matakieva-Lilkova, T. (2001). *The East-Christian art in Bulgaria.* Sofia, Bulgaria: Borina.

MINERVAEUROPE. (n.d.). *MINERVAEUROPE project: Ministerial Network for Valorising Activities in digitalisation*. Retrieved April 20, 2017, from http://www.minervaeurope.org

Noev, N. (2010). Organization and security of the audio and video archive for unique Bulgarian bells. *Mathematica Balkanica, 24*(3-4), 285-291.

Noev, N. (2015). Approaches and methodologies of creating, storing, presentation and protection of digital resources in the field of cultural and historical heritage via technologies based on knowledge. In D. Luchev (Ed.), *Proceedings of the Workshop "Innovation and Culture – Regional Problems and Solutions"* (pp. 19-28). Veliko Tarnovo: Institute of Mathematics and Informatics, BAS.

Pahal, N., Chauhan, N., & Sharma, A. (2007). Context-ontology driven focused crawling of Web documents. *Proceedings of Third International Conference on Wireless Communication and Sensor Networks, WCSN '07*, (pp. 121-124).

Paneva, D., Pavlova-Draganova, L., & Draganov, L. (2005). Digital libraries for presentation and preservation of East-Christian heritage. In D. Dochev, I. Simonics, & R. Pavlov (Ed.), *Proceedings of the HUBUSKA Second Open Workshop "Generic Issues of Knowledge Technologies"* (pp. 75-83). Budapest, Hungary: Institute of Information Technologies - BAS.

Paneva, D., Pavlova-Draganova, L., & Draganov, L. (2007). Towards content-sensitive access to the artefacts of the Bulgarian iconography. *Proceedings of the Fifth International Conference "Information Research and Applications" – i.Tech 2007*, (pp. 33-38). Varna, Bulgaria.

Paneva, D., Rangochev, K., & Luchev, D. (2007). Knowledge technologies for description of the semantics of the Bulgarian folklore heritage. *Proceedings of the Fifth International Conference "Information Research and Applications" – i.Tech 2007*, *1*, pp. 19-25. Varna, Bulgaria.

Paneva-Marinnova, D., Pavlov, R., Goynov, M., Pavlova-Draganova, L., & Draganov, L. (2010). Search and administrative services in iconographical digital library. *Proceedings of the International Conference „Information Research and Applications" – i.Tech 2010*, (pp. 177-187). Varna, Bulgaria.

Paneva-Marinova, D., & Pavlov, P. (2011). Educational application of top of digital library for cultural heritage. *Proceedings of the International Conference on e-Learning and the Knowledge Society (E-Learning'11)*, (pp. 211-224). Bucharest, Romania.

Paneva-Marinova, D., Goynov, M., & Luchev, D. (2014). Towards wider sharing of iconographical art content. In R. Pavlov, & P. Stanchev (Ed.), *Proceedings of the International UNESCO Conference on Digital Presentation and Preservation of Cultural and Scientific Heritage*, *4*, pp. 127 – 134. Veliko Tarnovo, Bulgaria. Retrieved April 27, 2017, from http://dipp.math.bas.bg

Paneva-Marinova, D., Pavlov, R., & Goynov, M. (2012). Two integrated digital libraries for knowledge and iconography of Orthodox saints. *Proceedings of the*

International Conference on Digital Heritage, EuroMed 2012 (pp. 684-691). Lemesol, Cyprus: Springer, Heidelberg.

Paneva-Marinova, D., Pavlov, R., & Rangochev, K. (2010). Digital library for Bulgarian traditional culture and folklore. *Proceedings of the 3rd International Conference dedicated on Digital Heritage (EuroMed 2010)* (pp. 167-172). Lymassol, Cyprus: ARCHAEOLINGUA.

Paneva-Marinova, D., Pavlova, L., Sapundjiev, V., & Bogdanova, M. (2014). Interactive environment for digital preservation and preservation of fashion objects. In R. Pavlov, & P. Stanchev (Ed.), *Proceedings of the UNESCO International Conference on Digital Presentation and Preservation of Cultural and Scientific Heritage* (pp. 147-154). Veliko Tarnovo, Bulgaria: Institute of Mathematics and Informatics, BAS. Retrieved April 27, 2017, from http://dipp.math.bas.bg

Paneva-Marinova, D., Pavlova-Draganova, L., Draganov, L., Pavlov, R., & Sendova, M. (2009). Development of a courseware on Bulgarian iconography for ubiquitous on-demand study. *Proceedings of Open Conference "New Technology Platforms for Learning – Revisited"*, (pp. 37-46). Budapest, Hungary.

Paneva-Marinova, D., Pavlova-Draganova, L., Pavlov, R., & Sendova, M. (2008). Cross-media and ubiquitous learning applications on top of iconographic digital library. *Proceedings of the 14th International Conference on Virtual Systems and Multimedia*, (pp. 367-371). Limassol, Cyprus.

Pant, G., Tsioutsiouliklis, K., Johnson, J., & Giles, C. L. (2004). Panorama: extending digital libraries with topical crawlers. *JCDL '04: Proceedings of the 4th ACM/IEEE–CS joint conference on Digital libraries* (pp. 142–150). ACM Press.

Pavlov, R., & Paneva, D. (2006). Toward ubiquitous learning application of digital libraries with multimedia content. *International Journal "Cybernetics and Information Technologies", 6*(3), 51-62.

Pavlov, R., Bogdanova, G., Paneva-Marinova, D., Todorov, T., & Rangochev, K. (2011). Digital archive and multimedia library for Bulgarian traditional culture and folklore. *International Journal "Information Theories and Applications", 18*(3), 276-288.

Pavlov, R., Pavlova-Draganova, L., Draganov, L., & Paneva, D. (2006). e-Presentation of East-Christian icon art. In D. Dochev, I. B. Simonics, & R. Pavlov (Ed.), *Proceedings of the Fourth HUBUSKA Open Workshop "Semantic Web and Knowledge Technologies Applications"*, (pp. 42-48). Varna, Bulgaria.

Pavlova-Draganova, L., Luchev, D., & Goynov, M. (2012). Modelling the functionality of the multimedia digital library for fashion objects. In R. S. Pavlov (Ed.), *Proceedings of International Conference "Digital Presentation and Preservation of Cultural and Scientific Heritage"*, (pp. 193 – 198). Veliko Tarnovo, Bulgaria. Retrieved April 27, 2017, from http://dipp.math.bas.bg

Pavlova-Draganova, L., Paneva, D., & Draganov, L. (2007). Knowledge technologies for description of the semantics of the Bulgarian iconographical artefacts. In T. Urbanova, I. Simonics, & R. Pavlov (Ed.), *Proceedings of the Fifth HUBUSKA Open Workshop "Knowledge Technologies and Applications"*, (pp. 41-46). Kosice, Slovakia.

Pavlova-Draganova, L., Paneva-Marinova, D., & Draganov, L. (2009). A use case scenario for technology-enhanced learning through Semantic Web services. *International Journal "Information Technologies & Knowledge", 3*(3), 257-268.

Pavlova-Draganova, L., Paneva-Marinova, D., & Pavlov, R. (2011). Ontological presentation of East-Christian iconographical art domain. *International Journal "Serdica Journal of Computing"*, 101-114.

Pavlova-Draganova, L., Paneva-Marinova, D., Pavlov, R., & Goynov, G. (2010). On the wider accessibility of the valuable phenomena of Orthodox iconography through digital library. In M. Ioannides, D. Fellner, A. Georgopoulos, & D. Hadjimitsis (Ed.), *Proceedings of the 3rd International Conference dedicated*

on Digital Heritage (EuroMed 2010) (pp. 173-178). Lymassol, Cyprus: ARCHAEOLINGUA.

Petrov, T. (1978). *Icons from Tryavna painters.* Sofia, Bulgaria: Septemvri.

Prashkov, L. (1985). *Bulgarian icons – progress, technology, restoration.* Sofia, Bulgaria: Septemvri.

Rangochev, K. (1997). Structural specifications of the folklore historical knowledge. *Problems of the Bulgarian folklore, 10*, 444-449.

Rangochev, K., Dimitrova, M., & Paneva-Marinova, D. (2012). Medieval sources and present-day folklore materials on saints in an electronic encyclopedia. In R. S. Pavlov (Ed.), *Proceedings of the Second International Conference on Digital Presentation and Preservation of Cultural and Scientific Heritage*, (pp. 172-176). Veliko Tarnovo, Bulgaria. Retrieved April 27, 2017, from http://dipp.math.bas.bg

Rangochev, K., Goynov, M., & Radoslavova, D. (2015). Electronic Encyclopaedia Slavica Sanctorum: report on the tendencies of use. In R. Pavlov, & P. Stanchev (Ed.), *Proceedings of the International UNESCO Conference on Digital Presentation and Preservation of Cultural and Scientific Heritage* (pp. 173 – 187). Veliko Tarnovo, Bulgaria: Institute of Mathematics and Informatics, BAS. Retrieved April 27, 2017, from http://dipp.math.bas.bg

REFLECTIVE-6-2015. (2015). *Innovation ecosystems of digital cultural assets*. Retrieved March 20, 2017, from http://cordis.europa.eu/programme/rcn/664970_en.html

Sapundjiev, V., & Luchev, D. (2015). Interactive environment for creating and preservation of fashion objects integrated with electronic storage of learning resources. *Doctoral Conference in Mathematics and Informatics, MIDOC 2015* (pp. 108-114). Sofia, Bulgaria: "St. Kliment Ohridski" University Press.

SINUS-Project. (n.d.). *Semantic technologies for Web services and technology enhanced learning, No. D-002-189 (Project web page)*. Retrieved March 20, 2017, from http://sinus.iinf.bas.bg

Stewart, S., Zheleva-Monova, M., Zhelev, Y., Pavlova, L., Luchev, D., Paneva-Marinova, D., & Pavlov, R. (2015). The Orthodox icons collection of the Regional Historical Museum—Burgas: A digital library for iconographic objects. In R. Pavlov, & P. Stanchev (Ed.), *Proceedings of the Fifth International Conference on Digital Presentation and Preservation of Cultural and Scientific Heritage* (pp. 157–172). Veliko Tarnovo, Bulgaria: Institute of Mathematics and Informatics, BAS. Retrieved April 27, 2017, from http://dipp.math.bas.bg

Su, C., Gao, Y., Yang, J., LuoSu, B., Gao, Y., Yang, J., & Luo, B. (2005). An efficient adaptive focused crawler based on ontology learning. *Proceedings of the Fifth International Conference on Hybrid Intelligent Systems (HIS'05)*, (pp. 73-78).

Trifonov, T., Dimokov, G., & Bogdanova, G. (2007). Study and passporting of unique bells of historical and cultural heritage of Bulgaria and creating audio and video archive with the help of modern technology. *Sixth National Scientific Conference "Libraries – Reading – Communications"*. Veliko Tarnovo, Bulgaria.

Tzouveli, P., Simou, N., Stamou, G., & Kollias, S. (2009). Semantic classification of Byzantine icons. *IEEE Intelligent Systems, 24*(2), 35–43.

Tzouveli, P., Simou, N., Stamou, G., Kollias, S., Kalomoirakis, D., Foukareli, G., & Fyssas, N. (2008). Sacred figure recognition based on Byzantine iconography knowledge. *Conference on Digital Heritage in the new knowledge environment: shared spaces & open paths to cultural content.* Athens, Greece.