Serdica J. Computing **4** (2010), 279–292

Serdica
Journal of Computing

Bulgarian Academy of Sciences
Institute of Mathematics and Informatics

SERVICES FOR CONTENT CREATION AND PRESENTATION IN AN ICONOGRAPHICAL DIGITAL LIBRARY*

Radoslav Pavlov, Desislava Paneva-Marinova, Maxim Goynov, Lilia Pavlova-Draganova

Abstract. 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 paper 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 autocompletion, reuse of values, bilingual entering of data, automated media watermarking, resizing and conversing. The paper 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

ACM Computing Classification System (1998): H3.5, H3.7.

Key words: Digital libraries, collection, systems issues, user issues, online information services.

*This work is partly funded by Bulgarian NSF under the project D-002-189 SINUS "Semantic Technologies for Web Services and Technology Enhanced Learning".

an important part of the content presentation. The paper also presents the overall service-based architecture of the library, covering its main service panels, repositories and their relationships. The presented vision is based on a long-term observation of the users' preferences, cognitive goals, and needs, aiming to find an optimal functionality solution for the end users.

1. Introduction. 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 the "Virtual Encyclopaedia of Bulgarian Iconography"[1] multimedia digital library (also called Bulgarian Iconography Digital Library, 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.

A key activity is related to the provision of flexible content creation and presentation. The research follows the accepted vision for simplifying and speeding up of the chosen activities, the provision of autocompletion and suggesting functions for resource annotation, and the provision of easy navigation and knowledge tracing during the browsing of content.

This paper presents the overall architecture of the "Virtual Encyclopaedia of Bulgarian Iconography" multimedia digital library (Section 2), covering the main service panels, repositories and their relationships. The paper also makes a detailed overview of the content creation, selection and preview from the architecture, presenting their functionalities and algorithms used (Section 4 and Section 5). The ontological model, describing the knowledge of East Christian Iconographical Art, is discussed in Section 3. This ontology is used for the annotation and semantic indexing of iconographical artefacts and knowledge included in the library.

[1]The first release of the library was created five years ago during the research project "Digital Libraries with Multimedia Content and its Application in Bulgarian Cultural Heritage" (contract 8/21.07.2005 between the Institute of Mathematics and Informatics, BAS, and the State Agency for Information Technologies and Communications), aiming to lay the foundations of the registration, documentation, and exploration of a practically unlimited number of Bulgarian icons [5, 7].

2. BIDL Architecture. The architecture of the "Virtual Encyclopaedia of Bulgarian Iconography" multimedia digital library contains two main service panels, *Object data management* and *Administrative services* (see Figure 1), 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. The export data services provide the transfer of information packages (for example, packages with MDL objects/collections, user profiles, etc.) compatible with other data base systems. For example, with these services a package with MDL objects could be transported into an XML-based structure for new external use in e-learning [2, 3, 4] or e-commerce applications. 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.

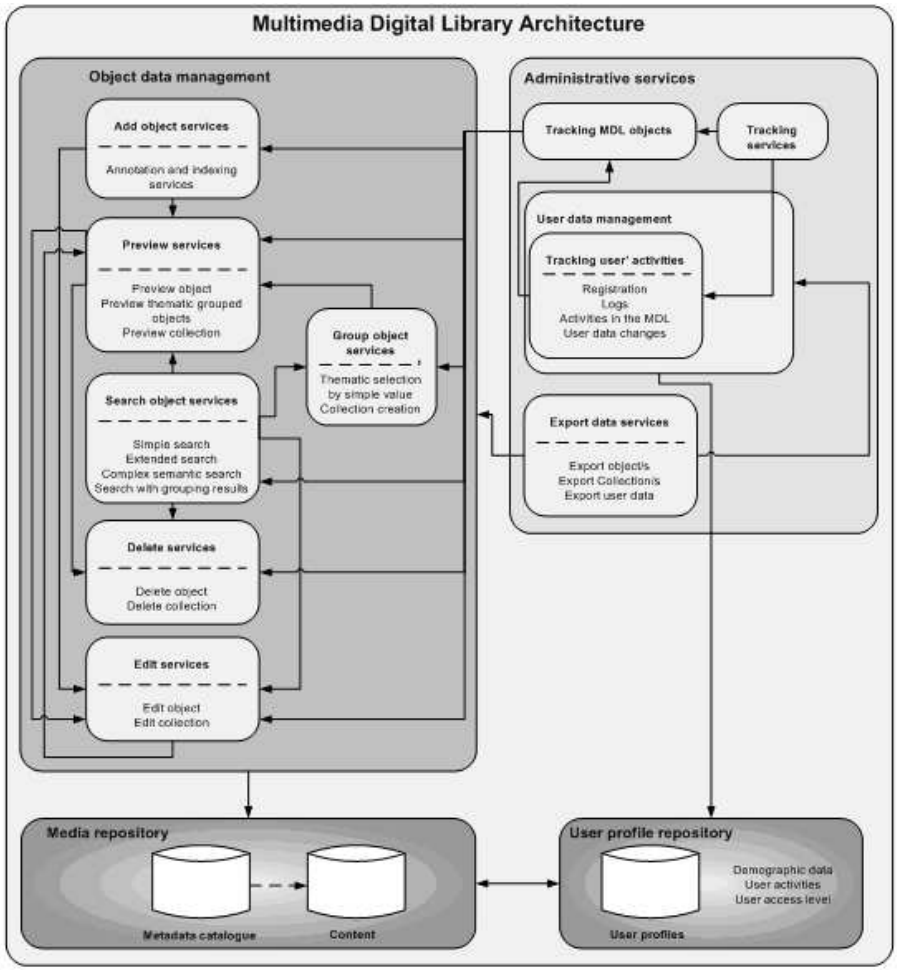

Fig. 1. BIDL Architecture

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.

3. Ontological Presentation of the Knowledge of East Christian Iconographical Art. The semantic metadata description of Bulgarian

icon art is determined by the domain ontology of East Christian iconographical art (also called iconography ontology).[2] This ontology includes main concepts, relations, rules, restrictions, individuals, and facts that are available in the iconographical art world. It also provides annotation patterns for the different types of informational resources, such as: an iconographical object (IO), an object presenting an iconographic school, an object presenting an author, etc.

During the observation of the iconographical art world, several ontological taxonomies were distinguished, such as an ontology of the iconographical objects, ontology of the iconographical schools, ontology of the authors of the iconographical objects, special ontology, temporal ontology, dimension ontology, ontology of the iconographical characters, ontology of the iconographical scenes, ontology of the iconographical symbols, ontology of the iconographical techniques, ontology of the base materials, varnishes, etc.

A key component of the iconographical art world is the iconographical artefact. The ontology of iconographical objects (artefacts) is presented in [1, 6]. The semantic description of the iconographical object covers three "thematic entities" (also called levels of knowledge). Every one of these entities is enriched with a set of sub-levels of the characteristics. The first one is the "Identification" entity, which consists of general data identifying aspects such as IO title, type, author and biographical data for the object's author, its clan, iconographic school, period, dimensions, current location and source, and object identification notes. The second entity 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, canonical type, iconographical scenes, character/s in the scene/s, symbol/s in the scene/s, detailed description of the depicted content. The third entity covers technical information revealing iconographic techniques, base materials, varnishes, gilding, 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.

These main entities and their metadata values are supported, documented and provided by the scientific diagnosis, which has been applied to the iconographical objects and collections.

Special attention has to be paid to the taxonomies of iconographical characters, scenes and symbols, and their description and interrelation. Every

[2]The ontology of East Christian iconographical art was developed during the project SINUS "Semantic Technologies for Web Services and Technology Enhanced Learning" (No D-002-189) and was used for the semantic annotation of the resources.

iconographical character/scene/symbol is depicted according to a special iconographer's workbook (called "hermeneia"). For example, all the details for the depicted character/s, such as face and hair characteristics, gestures, exposure, elements of clothing, objects held, background, etc., could be formally exposed and tracked.[3] In our work we try to find all the relations between separate characters, symbols and individuals in scenes demanded by the context. Using the formalism of the ontology approach we express these relations by ontological facts and rules. These facts also determine the presence of character/s and/or symbols in a scene as mandatory and/or possible and admissible. The separate character is associated with strictly determined canonical type/s (in some cases several canonical types). Some canonical types can appear in scenes without specifying their individuals. A more detailed description could observe the place of the characters in the scene, their activity, exposure and gestures, their clothing, surrounding details (things, objects, buildings, beings, ...), 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)[4], "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. Some of our concepts don't belong to the CIDOC CRM ontology.

The juxtaposing approach and some examples are included in [1].

The domain ontology of East Christian iconographical art is developed

[3]Such a detailed description is necessary for systems for automatic character detection/reasoning and for some very specialized applications for digital libraries. In our case such an extension of the ontological structure will be made if appropriate circumstances/applications appear.

[4]CRM is an official standard (ISO 21127:2006) since 9/12/2006. It is the culmination of more than a decade of standard development work by the International Committee for Documentation of the International Council of Museums. Its role is to enable information exchange and integration between heterogeneous sources of cultural heritage information. CRM aims at providing the semantic definitions and clarifications needed to transform disparate, localised information sources into a coherent global resource. More specifically, it defines and is restricted to the underlying semantics of database schemata and document structures used in cultural heritage and museum documentation in terms of a formal ontology. It explains the logic of what they actually currently document, and thereby enables semantic interoperability.

within the project SINUS "Semantic Technologies for Web Services and Technology Enhanced Learning" (No D-002-189) and is the basic data structure and annotation templates for the information objects in the "Virtual Encyclopaedia of Bulgarian Iconography" MDL [7].

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 "Virtual Encyclopaedia of Bulgarian Iconography" MDL 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:

— Autocompletion services: all used (already entered) field values are available in a special panel for reuse (see Fig. 2);
— Bilingual data entering with automated relation between the relevant values in different languages (see Fig. 2);
— 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 Fig. 2);
— A tree-based structure of the annotation template. Only checked fields are displayed for entering metadata (Fig. 2);
— Possibility for adding more than one media for one metadata description in order to create rich multimedia digital objects;

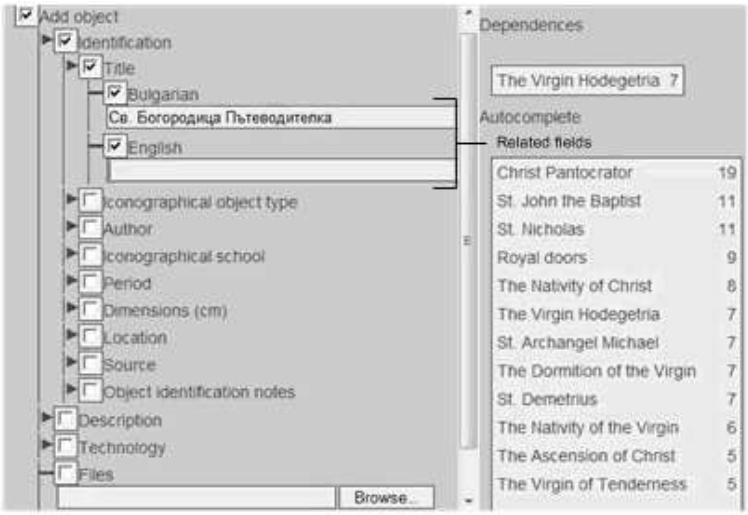

Fig. 2. Part of the annotation template of an iconographical object

— 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.

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 ($p_{ij} = \{r_{ij}, g_{ij}, b_{ij}\}$, $0 \leq r_{ij} \leq 255$, $0 \leq g_{ij} \leq 255$, $0 \leq b_{ij} \leq 255$).

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.

The standard coefficients are $k_1 = 0.3$, $k_2 = 0.59$, $k_3 = 0.11$, $0 \leq m_{ij} \leq 255$, 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 n is 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

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

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 doesn't 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 $p = \{p_1, p_2, \ldots, p_n\}$ be the set of all iconographical objects.

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

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

5. 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-hand frame of the preview window shows the description of the iconographical object. In the right-hand 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 a watermarking technique.

During the development of the 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 the iconographers (authors), and selecting one of them he can see additional biographic information and the collections of their work (see Fig. 3). A similar preview is available for the iconographic schools and regions/towns of physical object location.

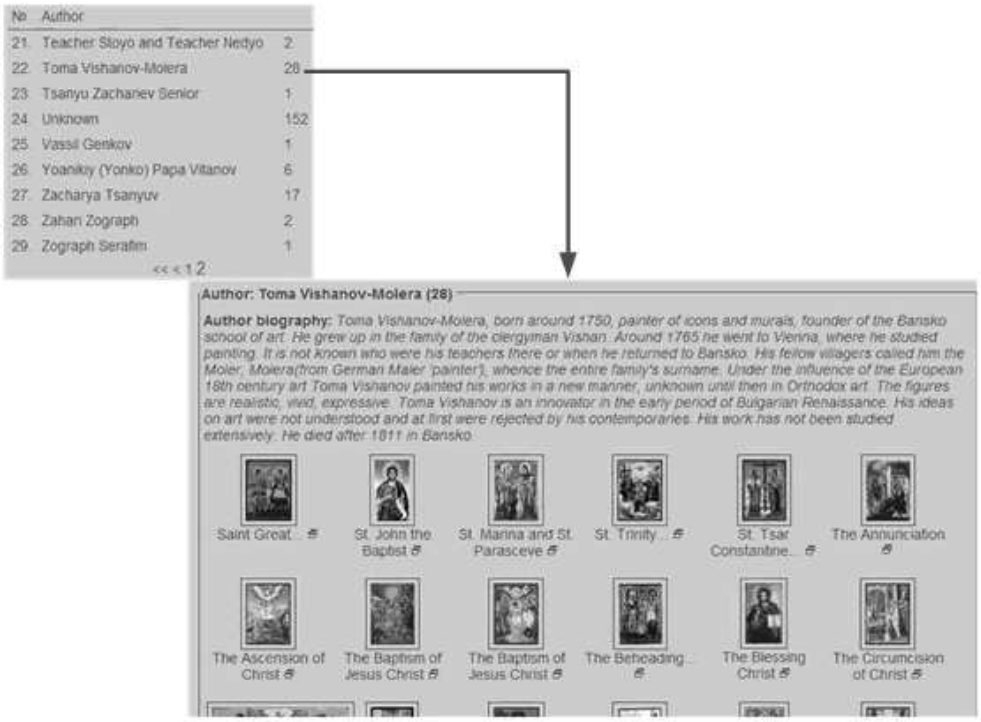

Fig. 3. Iconographical objects grouped by author criterion. A collection of icons made by Toma Vishanov-Molera

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 a short description. He can also select its status: private or shared with other users.

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

Let $P = \{p_1, p_2, \ldots, p_n\}$ 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 $M = \{m_1, m_2, \ldots, m_r\}$ be a set of characteristics for a collection $A_M = \{a_{M1}, a_{M2}, \ldots, a_{Mk}\}$ with k iconographical objects.

Let p_{ti} be a new iconographical object, added to the library, $P = P \cup \{p_{ti}\}$, and $M' = \{m'_1, m'_2, \ldots, m'_r\}$ be its set of characteristics.

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

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

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

$$Q = P \times T$$

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

Steps of the algorithm:

1. Create series $Q' = \{(p_{i_1}, t_{j_1}), (p_{i_2}, t_{j_2}), \ldots, (p_{i_d}, t_{j_d})\}$, where $t_{j_1} > t_{j_2} > \ldots . > t_{j_d}$
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$\{q_1, \ldots, q_v\} \in Q'$.

Conclusions. The rising new generation of information technologies is gradually alienated from software as a basic term and starts to consider mainly the services and functionalities offered to the users. The important services in contemporary digital libraries are: content creation, crawling, storage, browse, mea-

surement, retrieval, classification/categorization, filtering, clustering, summarization, mining, preservation, decision support, user modeling/personalization, etc. A main task for the developers is the proper design and intelligent implementation of these services. In this article we presented the architecture implemented in the "Virtual Encyclopaedia of Bulgarian Iconography" MDL 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 version of the BIDL. The main goal was the satisfaction of users' preferences and needs with appropriate navigation, visualization and content presentation techniques. The development of the latest version of the BIDL is also synchronized with the requirements of the SINUS use case scenario [8] involving the library in a different application: the development of learning and semantic resources for presenting Bulgarian iconographical art through the usage of Semantic Web Services.

The semantic and context-based search module and the administrative services panel will be presented in a separate paper because of their algorithm complexity and wide range.

REFERENCES

[1] Paneva D., L. Pavlova-Draganova, L. Draganov. Towards Content-sensitive Access to the Artefacts of Bulgarian Iconography. In: Proceedings of the 5th International Conference "Information Research and Applications"—i.Tech 2007 (ITA 2007—Xth Joint International Scientific Events on Informatics), 26 June–01 July, 2007, Varna, Bulgaria, Vol. **1**, 33–38.

[2] Paneva-Marinova D., L. Pavlova-Draganova, R. Pavlov, M. Sendova. Cross-media and Ubiquitous Learning Applications on Top of Iconographic Digital Library. In: Proceedings of the 14th International Conference on Virtual Systems and Multimedia, 20–25 October 2008, Limassol, Cyprus, 367–371.

[3] Paneva-Marinova D., L. Pavlova-Draganova, L. Draganov, R. Pavlov, M. Sendova. Development of a Courseware on Bulgarian Iconography for Ubiquitous On-demand Study. In: Proceedings of Open Workshop "New Technology Platforms for Learning—Revisited" (Ed. A. Szűcs), January 2009, Budapest, Hungary, 37–46.

[4] Pavlov R., D. Paneva. Toward Ubiquitous Learning Application of Digital Libraries with Multimedia Content. *International Journal "Cybernetics and Information Technologies"*, **6** (2007), No 3, 51–62.

[5] Pavlov R., L. Pavlova-Draganova, L. Draganov, D. Paneva. e-Presentation of East Christian Icon Art. In: Proceedings of the Open Workshop "Semantic Web and Knowledge Technologies Applications", 12 September, 2006, Varna, Bulgaria, 42–48.

[6] Pavlova-Draganova L., D. Paneva, L. Draganov. Knowledge Technologies for Description of the Semantics of the Bulgarian Iconographical Artefacts. In: Proceedings of the Open Workshop "Knowledge Technologies and Applications", 31 May – 1 June, 2007, Kosice, Slovakia, 41–46.

[7] Pavlova-Draganova L., V. Georgiev, L. Draganov. Virtual Encyclopaedia of Bulgarian Iconography. *International Journal "Information Technologies and Knowledge"*, **1** (2007), No 3, 267–271.

[8] Pavlova-Draganova L., D. Paneva-Marinova, L. Draganov. A Use Case Scenario for Technology-Enhanced Learning through Semantic Web Services. *International Journal "Information Technologies and Knowledge"*, **3** (2009) (in print).

Radoslav Pavlov
Desislava Paneva-Marinova
Maxim Goynov
Department of Mathematical Linguistics
Institute of Mathematics and Informatics
Bulgarian Academy of Sciences
Acad. Bonchev Str., Bl. 8
1113 Sofia, Bulgaria
e-mail: radko@cc.bas.bg
e-mail: dessi@cc.bas.bg
e-mail: maxfm@abv.bg

Lilia Pavlova-Draganova
Laboratory of Telematics
Bulgarian Academy of Sciences
Acad. Bonchev Str., Bl. 8
1113 Sofia, Bulgaria
e-mail: pavlova.lilia@gmail.com

Received March 18, 2010
Final Accepted April 29, 2010