DESIGNING INTEROPERABLE MUSEUM INFORMATION SYSTEMS

Dimitris Gavrilis [a,], Giannis Tsakonas [b], Christos Papatheodorou [a,b]

[a] Digital Curation Unit, Athena Research Centre, Athens, Greece – d.gavrilis@dcu.gr
[b] Department of Archives and Library Sciences, Ionian University, Corfu, Greece – john@lis.upatras.gr,
papatheodor@ionio.gr

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ABSTRACT:

Museum collections are characterized by heterogeneity, since they usually host a plethora of objects of categories, while each of them requires different description policies and metadata standards. Moreover the museum records, which keep the history and evolution of the hosted collections, request proactive curation in order to preserve this rich and diverse information. In this paper, the architecture of an innovative museum information system, as well as its implementation details is presented. In particular the requirements and the system architecture are presented along with the problems that were encountered. The main directions of the system design are (a) to increase interoperability levels and therefore assist proactive curation and (b) to enhance navigation by the usage of handheld devices. The first direction is satisfied by the design of a rich metadata schema based on the CIDOC/CRM standard. The second direction is fulfilled by the implementation of a module, which integrates the museum database with a subsystem appropriate to support user navigation into the museum floors and rooms. The module is expressed as a navigation functionality, which is accessed through handheld devices and peripherals, such as PDAs and RFID tags. The proposed system is functional and operates into the Solomos Museum, situated in Zakynthos island, Greece.

1. INTRODUCTION

Museum collections are characterized by heterogeneity not only regarding their collections, but also due to the plethora of the different services they provide. It is typical for a museum to provide its employees with tools for collection management through different metadata schemata, collection history and evolution, web site management, collection information preservation etc. Having entered the information age, modern museums provide their visitors with services like interactive tours (through mobile devices), educational applications, etc.

In order to provide all these services, a complex information system is required. In this paper, an information system is presented integrating a number of innovative services and has been in operation for the last year in the Solomos Museum situated in Zakynthos island, Greece. A basic requirement of the system is its compatibility with the CIDOC/CRM standard. Thus, all the information inserted in the museum database must be mapped to the CIDOC ontology.

In the following sections the architecture of an information system called Digital Museum Management System (DMMS) is presented along with its application study and the challenges that arise during its development and operation.

2. RELATED WORK

The growth of cultural heritage information systems field and the maturing of ideas, concepts and demands have lead to the evolution of software applications to address the numerous needs that each and every phase of digital museums requires. Digital museum management systems are growing in number providing a set of options, but also are exhibiting remarkable quality leverage. The MuseTech Registry (http://www. musetechcentral.org/), which is jointly developed by the Museum Computer Network and the Museum Software Foundation, lists several digital museum applications in areas like digital asset management, collection management, publication, digitization, gallery and kiosk development and so on. This highlights the increasing and varied demand in specific areas of the museum information flow and the mature response of the community.

Regardless of the system development approach, two issues are explicitly required in digital museum applications; system flexibility and adaptation to user needs. The satisfaction of these two requirements faces many difficulties due to the heterogeneous material hosted in museums. In a museum a variety of two and three-dimensional objects may exist, such as pictures, clothes, furniture, etc. Moreover a diversity of visitors have access to its physical and digital collections, with different goals, e.g. educational, research in several domains such as history, archaeology, anthropology, sociology, etc. and of course for touristic and entertainment purposes. Referring to digital collections, metadata schema design is a very crucial process which is closely related with the fulfilment of the mentioned requirements since it is the mean for managing and revealing all the important attributes of the museum collections. As Chen et al. (2002) report, there are seven stages in metadata development, namely analysis of collections' attributes, collection and analysis of user, interoperability, semantic design of metadata, development of metadata management systems, development of tagging guide and user manuals and provision of training courses.

Moreover the enhancing capabilities that the technology provides allow viewing the museum objects management under various perspectives. The proliferation of specialized museum management software gives the chance to detach useful

information from application types and models of interaction that belong to other domains. Tang proposes new ways of presenting and accessing digital objects and collections in a digital museum that are adjusted to the contextual needs emerged by this environment, such as narrative-centred, object-centred and information centred (Tang, 2005).

Patel et al. (2005) respond to the metadata creation challenge for museum application by approaching not only the systemic aspect of development, such as functional requirements or interoperability, but by giving emphasis to the user requirements as well. They emphasize on the role that each user class has in the development of museum metadata.

3. SYSTEM DESCRIPTION

Typical design requirements of a digital museum management system include:

- The comprehensive and precise recording of the cultural heritage items.
- The security and integrity of the digital assets and its respective metadata.
- The support of effective administration and documentation of the digitized material.

The proper design of an application acquires great importance in museum applications for two reasons: (a) the museum items in a variety of forms (such as two dimensional items - paintings, documents, manuscripts and incunabula - and three dimensional items - sculptures, music instruments, guns and armory) and carry meaningful information which need particular handling; (b) furthermore the corresponding metadata are often used by a variety of applications, like websites, portals, interactive applications and mobile computing devices, and therefore different views of the same information are required in order to augment the technical aspect of the contextual information retrieval.

3.1 Syntactic Interoperability

Referring to the information structures that are required for cultural heritage documentation, three categories of metadata element occurrence are needed for the proper description of an item:

- *Necessary*, where element and subelements values are indispensable for the correctness of the record.
- *Mandatory*, where element and subelements values are given if they exist and are known to the museum personnel.
- *Optional*, where element and subelements values are given if the data exist and when the economy of the whole process allows it.

Furthermore each field can receive multiple values if the precision and the extensiveness of the record request it. Therefore the level of multitude of values is divided to the following categories:

- Unique, where only one value is required and allowed.
- Multiple, where more than one values are allowed.

The above mentioned syntactic rules could be expressed by an XML Schema which defines a metadata language able to express and exchange machine readable metadata structures.

3.2 Semantic Interoperability

In order to achieve a satisfactory level of semantic interoperability, the default metadata schema of the application was designed in order to support correspondence with the CIDOC Conceptual Reference Model (CIDOC/CRM) (Kalomoirakis et. al., 2005). CIDOC/CRM is jointly developed by CIDOC Documentation Standards Working Group and CIDOC Special Interest Group in CRM, while from September 2000 it is a draft ISO standard (ISO/CD21127). The principal aim of CIDOC CRM is *"to enable information exchange and integration between heterogeneous sources of cultural heritage information"* (ICOM/CIDOC Documentation Standards Group, 2008). In particular CIDOC/CRM aims at the standardized expression of cultural information and the semantic definition of concepts and relations, which are needed for local access constraints. According to formal target statements CIDOC/CRM aims to *"serve as a basis for mediation of cultural heritage information and thereby provide the semantic 'glue' needed to transform today's disparate, localised information sources into a coherent and valuable global resource"*, but also allows potential extensions for adaptation reasons in specialized applications. CIDOC/CRM does not dictate the data for cultural documentation, like for instance standard types of terminology, which may derive from the specific character of the collections, but premises the need for a common platform of documentation and interpretation of cultural events and concepts. CIDOC/CRM in application settings consists of an object-oriented semantic standard, which may be transformed into machine readable formats, such as OWL.

3.3 Records Management

The application addresses needs of (a) digital surrogates import and (b) metadata import and editing, in order to create the appropriate information items for the end-user applications. In detail the application allows the following activities to be performed:

- *Import of high and low resolution digital images*. During the creation of a record the authorized user can import a digital image, which corresponds to the physical item of the museum. Finally the user can choose a digital surrogate and edit them with other assisting applications in order to improve their quality.
- *Import of descriptive data of the digital items*. Authorized users can import all data available to describe and identify accurately the specific item, like name, number, way of acquisition etc. During this stage the user can assign potential relationships between the items, to import descriptive texts, to import multimedia files and so on.
- *Metadata editing*. Authorized users can edit metadata for correction or enrichment purposes of the existing records.

The metadata import interface is exploiting data entry techniques in order to eliminate chances of mistyping or to quicken the process. Also implements the creation of authority

files for names and terms in order to ensure uniformity and cohesion in the terms of the database.

3.4 Architecture

The main application's database communicates with a second database, called assistant database, which stores duplicates of the records in specialized formats linked with the peripheral end-user applications, such as the navigation application. In parallel the assistant database can record the data that are created automatically from real-time interaction and to store them for future processes.

By choosing to use two distinct databases, the architecture enhances the security and the integrity of the data. The peripheral applications retrieve data from the assistant database and deliver them to the end-users. Moreover these applications store in the same point the behavioral and interactional data of the end-users. The system does not allow data import or export from and to the main database, protecting thus the digital surrogates and their metadata. The two databases work in parallel for preserving and securing the data in case an external factor leads to faults in the operation of one of them. This approach however has the side effect of the constant synchronization of the two databases.

The assistant database is responsible for the following operations:

- Collection and storage of the end-users' information (identity data). These data are available to the main database in order to identify the user and provide the respective level of authorization.
- Collection and storage of users' behavioral data. The database records data of the users' behavior as they interact and they request information through the various applications. For example the database records data from the users' interaction with the mobile devices within the museum's space, like paths and node points where the user showed interest (through consultation of the RFID cards in various exhibits). Administration of personal data that are collected in the assistant database are in conformity with arrangements concerning protection of sensitive data. Moreover these data are stored and maintained in the assistant database for a predefined period and then are deleted.
- Collection of users' messages/comments. The assistant database collects all comments and annotations the users deposit during their visit in the museum and their walk through the exhibits. The database allows to the end users administration application the view of all message and comments deposited by the visitors, giving thus the chance to increase social interaction infrastructures in the museum.

3.5 Classes of Users

Two are the categories of users that have rights to access the DMMS.

- *System administrators*. The specific user class includes the specialized technical personnel of the museum, which operates the database application and the museum information system application. The specialized technical personnel has full rights of administrating structures of the system, such as fields and database tables, while can create new user accounts.
- *Museum personnel*. The specific class of users can access the system after the system administrators have created accounts, which gives them rights to import, edit and delete information items.

The next sub-section presents the modules of the first class of users, namely the system administrators, while the second sub-section presents the modules for the second class of users, the museum personnel.

3.6 System Administrators Modules

Personal Settings

Through this module the system administrators can edit the settings of their account.

Services Administration Module

System administrators are able to create and import new services and modules, while they are also able to edit existing ones. System administrators have to create a new service by following guidelines in the system documentation manual and applying code editing, and shortly after, through the graphical interface, they can activate the new service.

User Administration Module

System administrators can add or delete users of the Digital Museum Management System (DMMS). Moreover system administrators have the ability to define the level of access of each user of the application and to grant access rights to specific services.

3.7 Museum Personnel Administrators Modules

Announcement Administration Module

The museum personnel can import, view and edit announcements regarding the operation of the museum through the application. The Announcement Module can connect directly with the website or the web portal of the museum, without the intervention of a webmaster. The user can import edit the following fields:

- *Title*: The title of the announcement.
- *Text*: The main text of the announcement.
- *Date*: The date of creation.
- *Visibility*: The level of visibility of the announcement.

Groups Administration Module

The museum personnel can import, view and edit groups of assets. The application acknowledges that some groups can have items that belong to more than one team. Through the Groups Administration Module, the museum personnel can import data in the following fields.

- *Name*: The name of the group of digital assets.
- *Comments (Personnel)*: Information about the group of assets that addresses to the technical or museum personnel and should not be visible to public.

- *Comments (Public)*: Information and comments about the group that need to be presented to the visitors of the museum in order to comprehend the nature of the group.
- *Visibility*: The museum personnel can define if the information about the group will be visible to all visitors.

Digital Assets Administration Module

This section is one of the most important of the DMMS, as it offers to the museum personnel the ability to describe the digital assets and correlate them with other entities, like groups of assets or persons. The museum personnel are able to view all available assets, to import a new one and to edit them. However they need to fill a first set of fields in order to create the record, which are:

- *Identity data*: Information that gives comprehensive information for the title of the asset and that identify it among the many assets, like *name* (the name of the museum item), *code* (an identification alphanumeric code of the item in the archives of the museum) and *local name* (a contextual name of the item).
- *Classification data.* Information that classifies an asset in wider entities, like *group* (the name of the team in which an item belongs) and c*ategory* (information about the category in which an item is part of, according to a predefined scheme of the museum.
- *Description and Commenting of the item.* Free text for the commenting and description of the asset, like d*escription* (a field of free text for the description of the item and its attributes), c*omments* (any comments about the item) and v*isibility* (the museum personnel defines if the asset will be visible on the website).

After the completion of this first set of data, the museum personnel can navigate through a second class navigation tab-designed bar in order to fill information about the digital asset.

- *General metadata*: This tab contains most of the information that the user imported. New fields (optional) require a characterization of the item (Classification data), information about the creation of the museum item, such as place, date, material, weight, technique, name of manufacturer and authenticity (Manufacturing information), information about the use, such as place, date, purpose, population, season, way of use (Use of item), information about its acquisition (date, place, previous possessors, way of acquisition, e.g. donation), value (price, currency) and formal documents related to its acquisition (invoice, type of document and date), information about its scientific documentation, such as folders and subfolders of related information, and finally information about the removal of an item from the Museum (e.g. way of removal, formal document, date, new possessor and so on).
- *Relationships editing*. The museum personnel can correlate digital assets in order to highlight the collection's structure and characteristics.
- *Text Files*. Entry of texts for the various applications.

- *Media Files*. Entry of media files (images, moving image files, sound files) that relate to the museum item and need to be presented.
- *Bibliography*: Information about books and other items of literature that relate to the item, such as type of literature (e.g. book, article), code, title, file and comments.
- *Exhibitions*: The museum personnel can link the specific item to exhibitions that has taken part.
- *Research*: Information about the type of research that has been conducted based on the specific item, such as type of research, description, date of research, date of report publication).
- *Position*: information about the current position of the item, such as date, position and comments.

Authority Files Module

This module offers to the museum personnel the ability to import and authorize personal names and subject terms related to the museum items (see Figure 1).
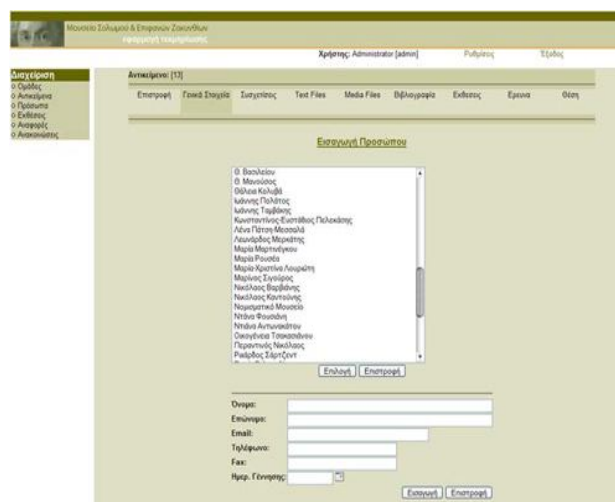

Figure 1: Authority Files Module screenshot of the Application Case Study

Reports Module

The current module allows the museum personnel to generate reports of multimedia files and their associations with the museum items in the database.

Exhibitions Administration Module

In this module, the museum personnel can import new entries of exhibitions that the museum items have taken part. The personnel need firstly to create a record for the exhibition and then to relate the item with the exhibition from the Digital Assets Administration Module.

4. APPLICATION STUDY

4.1 Setting

The scope of the project *"Museum of Solomos, Kalvos and other eminent Zakynthians"* (henceforth Museum of Solomos) was to build a digital repository and to provide a set of services that focused on the support of digital collection management

and on the assistance of visitors' contextual activities. The main set of services includes the design and implementation of a web portal and the implementation of supporting infrastructures for the development of museum navigation applications using mobile devices. In the web portal the visitors can learn more about the Museum, its exhibits and collections, as well as prepare their visit and to pre-organize educational activities. The navigation application allows visitors to explore the Museum assets with the use of a mobile device and to take part in educational activities, augmenting thus the experience within the museum. The selection of the digitized material was concluded in close cooperation with the personnel of Museum of Solomos and the total number of items exceeded 2.000.
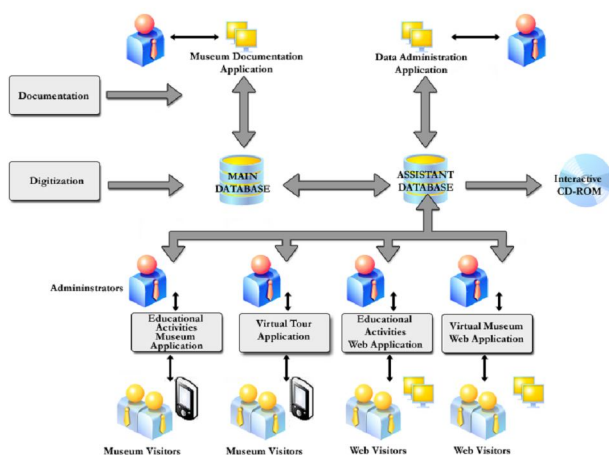

Figure 2: Application Study Architecture

The assistant database also stores the selected material used for the design of an interactive CD-ROM for the presentation of the museum. The main database stores the digitized surrogates and is linked with the Museum Documentation Application, which is supervised by the system administrators, while a second system administrator monitors the operation of the assistant database and handles the stored data (see Figure 2).

The whole system has been developed using a Php-MySQL platform. The main reasons for using this platform was its portability (can be used in most operating systems and servers) and its ease of implementation. It should also be noted that the platform does not require any special php libraries and all functionality is developed from scratch, thus making it more robust. The platform is modular and various modules have been developed for carrying out most of the tasks described in this paper. The functionality described in the previous sections is implemented in the following modules with the first module carrying most of the complexity:

- Item module: insert/edit item properties
- Group module: insert/edit item groups
- Person module: insert/edit person authorities
- Reports module: produce reports for the museum
- Settings module: administer system modules/users

Users access the system and to each module through the user management facilities of the platform which allow each user to be given specific access to each module. The platform also allows the export of the museum items to XML according to the CIDOC/CRM standard. Being an open source system, a skeleton module is also supplied along with a simple yet comprehensive development guide in order for the museum administrator to be able to add new functionalities to the system.

4.2 Challenges

The challenge for the development team was to provide a unified schema that would:

- conform to the metadata interoperability guidelines expressed by a set of Document Type Definitions (Kalomoirakis et. al., 2005), dictated by the project supervising authority (Information Society Secretariat, Greece), in order to augment linkage and information exchange with other collections that constitute the national cultural heritage digital inventory,
- ensure semantic relationship of similar items and thus supporting semantic interoperability as guided by the implementation of CIDOC/CRM (see Table 1) and
- preserve valuable information concern the museum wealth and enhance the effective information retrieval from the various access applications offered to local and remote users.

The museum material was described in printed storage forms of archival description, which were designed and provided to the Museum of Solomos from the Greek Ministry of Culture and most specifically from the Headship of Cultural Heritage (former Headship of Popular Culture). These printed forms represent the long-term tradition of recording museum exhibits and through the use of specific fields it is highlighted the significance of specific parts of museum information. Many of these fields are necessary ingredients of the museum metadata schema, which could not be ignored during its conduction.

The form included the following grouped information:

- *Identification and Description information*: This information were concerning the entry number or any other former identification number, the category of the item, the number of its constituent parts, quick description, local labeling and its authenticity characterization.
- *Manufacturing information*: Details about the spatial and temporal dimensions of its manufacturing, its author, materials and techniques needed, dimensions and weight.
- *Usage information*: Information that help replication of the aim and the context of use of a specific museum item. It refers to the spatial and temporal dimensions of use, the population using it and the way of usage.
- *Acquisition information*: Details about the way of acquisition from the Museum of Solomos. It refers to spatial and temporal information of acquisition, the way of acquisition, former possessors, value and formal documents proving its acquisition.
- *Free Text information*: Area of free text commenting and annotation of aspects of the item that could not enter in other fields.
- *Archival information*: This information was divided in sub-categories that referred to the archival folders

of the forms, its current position and the aims of research that was conducted based on this item.

Despite the comprehensiveness of the form for the recording of each item, a synthetic approach is needed in order to achieve the convergence with the requested standards, which qualify syntactic and semantic interoperability. Furthermore the printed forms responded to needs of earlier time periods, where the conceptual approach was object oriented. However recent developments allow a directional shift by focusing on the event-oriented replication of museum items. One specific example of this shift is the highlighting of the relationships between the items, which occur as a result of the contextual parameters. It is obvious that in a physical space, like the museum floors and halls, users maintain their own self-activity and they follow their own paths of exploration. Therefore supporting applications, like labeling or mobile peripheral access, the visitor should be self-sufficient to gather all data required for the whole view of the events, the concepts and the historic context in general. These semantic relationships allow the synthesis of the surrounding world of the item.

Field title	Creator_id
Definition	The name of creator (manufacturer, artist etc) of the museum item.
Sub-fields	-
Occurrence (Entry)	Optional
Occurrence (Multitude)	Multiple
Accordance with DTD	Manufacturer [person]
Accordance with CIDOC/CRM	E12 Production: P14 carried out by /performed: E39 Actor

Table 1. Instance of a mapping between the Digital Museum Management System database, DTD and CIDOC/CRM.

4.3 Mobile navigation

The Solomos Museum also features a mobile navigation sub-system which utilizes a Windows mobile PDA equipped with an RFID card reader and an application that offers to the visitors a number of services allowing them to:

- locate certain items and navigate to them from any location in the museum,
- view information about items and relate items with each other, and
- provide visitors (especially students) with educational applications (e.g. games).

DMMS supported this specific application, by supplying links between certain elements of the items' metadata and the mobile devices and by rendering the information for the proper presentation (e.g. small screen size). Details regarding the mobile application architectures, services and applications can be found in (Cabrera et al. 2005).

5. CONCLUSIONS

In conclusion, the design and implementation of a museum management system named Digital Museum Management System was presented in this paper (DMMS). DMMS consists of modules for storing information about the museum items and exporting some of this information (a) to the museum's portal (providing information to the online visitors) and (b) to the mobile devices (providing location services and educational functionalities). Apart from the complex design of the system, most metadata elements had to be mapped to the CIDOC/CRM ontology so that all knowledge inserted into the system is semantically annotated and interoperability with other similar applications is possible. DMMS is on continuous development by integrating new designing recommendations and by applying suggestions for further improvement.

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