

“BYZANTIO”: An ontology based system for the conservation treatment documentation of artworks

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1. Introduction

The exclusive occupation of the Conservation Laboratories of the Museum of Byzantine Culture in Thessaloniki is the conservation of the artefacts of the Museum's collections. The complex manufacture technology of the icons, ceramics, marbles, etc, the perplexity of the painting materials and their stratigraphy cause equally complex problems regarding their conservation. The documentation methodology is applied in ways dictated by the relevant international conventions: classification, pathology diagnosis, manufacture technology examination and specification of maintenance condition. In sequence, the conservation procedure integrates with practices accepted by the international scientific community. All the above result in the accumulation of a great load of complex data and metadata. Aiming mainly in the constructive use of that information, the need for the development of a bottom up system for the systematize and management the documentation data from the various stages of the conservation procedure came up. This system unifies the registration and documentation of all the art objects belonging to the collections of the Museum, throughout all stages of the work undertaken in the conservation

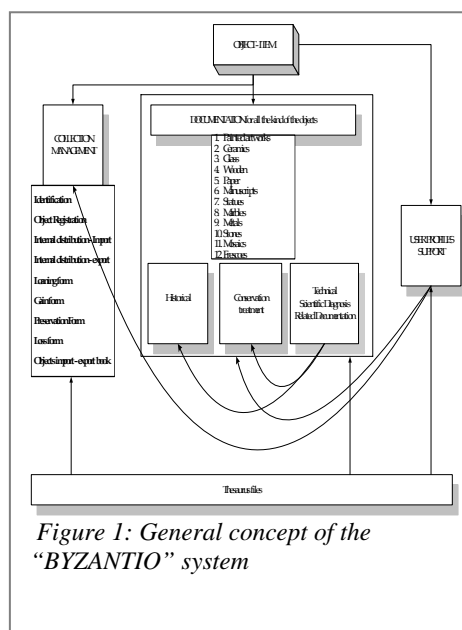


Figure 1: General concept of the
“BYZANTIO” system

laboratories, the photographic workshop, the temporary and permanent storage areas and the exhibition galleries. Responding at the multifold needs of the scientific (and not only) documentation of artworks within a museum the multi-level “BYZANTIO” called system is designed and developed such as a powerful multi-information database tool corresponding to the before described needs providing:

- Documentation / archiving of multidimensional data coming from the diagnosis and conservation treatment of the objects providing the possibility to cognitively modeling and semantically formalization of these data for indexing and retrieval of the information based on the conservation science domain knowledge.
- Processing, indexing and retrieval of technical examination data and metadata (multispectral imaging and spectral information) for the documentation of artworks.
- Collection management system such as storage, loan, exhibition, condition reports etc

Trying to meet the needs of the Conservation Laboratories of Museum of Byzantine Culture in Thessaloniki an authoring based, ontological system is developed treating in the same system the documentation of the conservation of different kind of objects: 1. Icons, 2. Ceramics, 3. Glass, 4. Wooden, 5. Paper, 6. Manuscripts, 7. Statues, 8. Marbles, 9. Metals, 10. Stones, 11. Mosaics, 12. Frescoes, etc. The cognitive models are structured descriptions of the knowledge domain (in this specific case of the Conservation treatment) and the semantic formalization is the use of the appropriate terms in the structure of the cognitive models.

1.1 Comparison with other systems - state of the art

Up today there is not a bottom up system covering the management of the collection within a Museum operation, the scientific documentation (Historical and technical), the conservation treatment that is followed sensitive to the different kinds of objects and all of that being user “sensible” ensuring the security of the data that is stored. There are plenty of systems covering mainly the collection management part as well as the management of the digital data (images, video and audio) concerning artworks that belong to a collection [1,2]. There has never been a more pressing need for organisations to control and manage their digital assets in an efficient manner. As resources are increasingly “born digital” and moreover stored in digital form, the management and monitoring of these valuable assets through their entire lifetime has become essential. Digital assets typically cycle from creation to multiple and varied uses and changes, and later into archives from which they may be quickly and accurately recalled and repurposed. Many types of file may be considered as digital assets, from images, audio files and rich media/multimedia files to Web pages,

progressive drafts of text files, and product brochures. There are some commercial products (Digital Asset Management Systems, DAMS)[4] that provide the tools to ingest, index, categorize, secure, search, transform, assemble, and export content in as many forms as an organization requires. However, all these commercial products offer solutions for professionals working in the cultural heritage field, and thus, knowing this area very well and knowing what they have as content to be stored in the DAM system very well. Therefore, we can say that the main objective of DAMS is not to promote culture but to help specialists manage their collections of art. Also, these DAM Systems are very content centred, in the sense that they are not general at all and they can have accuracy and consistency problems as well as database management and connection difficulties. DAMS are also focused on the Return of Investment and therefore, they are tools that cannot be afforded by many cultural institutions in order to promote their culture. DAMS are very expensive and cultural institutions need specialized staff that have the sufficient and knowledge to use them. Another weak feature of the system is that it is not compliant with standards currently used in the cultural heritage field, e.g. Dublin Core, CIDOC CRM, etc., not enabling this way the reuse of content. And although it can manage XML based documents they are not fully XML compliant. The described system covers all the levels of a museum activities having as a target the documentation of the objects of the museum being compatible with the international standards for museum collection management still proposing a concrete solution for the development of new forms and methods for the conservation science treatment documentation. In the following paragraph all these levels are extensively described. The described system including the content browsing tool and the authoring interface provides the user with the possibility to describe the stored knowledge using the available standards (Dublin Core, CIDOC CRM, etc) still develop additional proposals to the standards.

2 Description of the thematic entities of “BYZANTIO” system

The thematic entities of such kind a system are dictated by the way that the museum treats an object. The trace of the object while this is imported to the Museum collection is the following:

- The object is registered
- The historical and provenance data of the object are shortly studied and stored
- The object according it's special characteristics is registered in the special sub collection (icon, marble, etc)
- The object is registered in the inventory of the Museum

After these initial procedures the object is ready to be documented as far as the historical placement and the conservation treatment is

concerned. So the object depending on its kind is registered to a specific conservation laboratory for the diagnosis (scientific and technical examination) and conservation procedures.

After the bottom up documentation and conservation in the laboratories the object is chosen for the permanent or temporary exhibition of it. The documentation methodology is applied in ways dictated by the relevant international conventions: classification, pathology diagnosis, manufacture technology examination and specification of maintenance condition. The conservation procedure integrates with practices accepted by the international scientific community. Consequently and in accordance to the above described museum operations the main thematic entities (parts) of the system are:

1. Object identification and management (Collection management)
2. Object diagnosis documentation (Digital Data - provided by the scientific examination - diagnosis)
3. Object conservation treatment documentation (Conservation)
4. User administration – user profiles support (User Administration)
5. Thesaurus files management

This structure is not a structure of a common system that is constituted by separate subsystems, but these subsystems have an operational relation among them that depict to the overall operation of the museum. Each of these parts are mainly based to the scientific documentation of artworks (figure 1):

1. Collection management
2. Documentation : (Scientific diagnosis, Conservation treatment, Historical placement).
3. Administration:(Users, laboratories and user profiles)

The scientific and technical examination reveals data and metadata that feed all the parts of the system. The way that a museum operates imposes the parameterisation of the users according to the laboratory that they belong and the kind of access that they will have to the data. Each thematic entity is epigrammatically described in order the technical description to be optimally comprehended.

2.1 Collection management

The collection management parts of the “BYZANTIO” system are based and feeded by the data produced for the documentation of the art objects procedures.

The collection management entity is compromised by the following parts (figure 2): 1.Object registration to the collection of the Museum, 2. Object identification, 3. Object condition reports, 4. Object loaning, 5. Object import and export to the conservation labs, 6. Object loss, 7. Inventory. The file of the object (ITEM) has a relation with each file of the collection management thematic entity of 1:N.

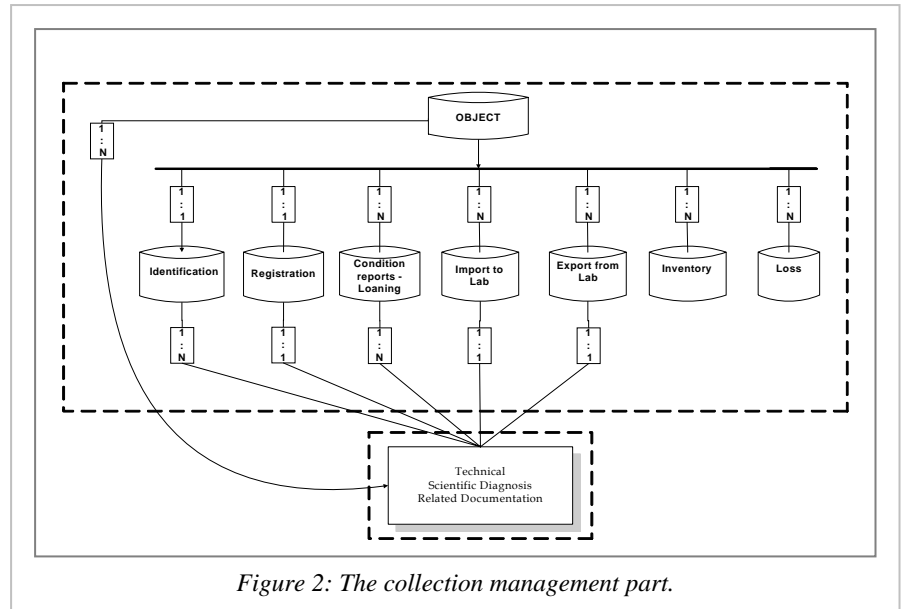


Figure 2: The collection management part.

2.1.1 Object registration

The object registration is the procedure with which the object is registered to the collection having assigned to it an ID and in which Laboratory of the Museum belong. An inventory ID also is assigned to this object simultaneously.

2.1.2 Object identification

The identification of the artwork describe the main characteristics of the artwork such as: 1. School, 2. Creator, 3. Historical data, 4. etc

2.1.3 Object condition reports

The state of preservation in general as well as before each movement of the object for different reasons (loaning, exhibitions, restoration, etc) is registered.

2.1.4 Object import / export to the conservation labs

All the object transactions within the museum operation is also registered.

2.1.5 Object loss

The loss of an object is also registered describing the conditions and the cause of the loss.

2.2 Diagnosis documentation (scientific data)

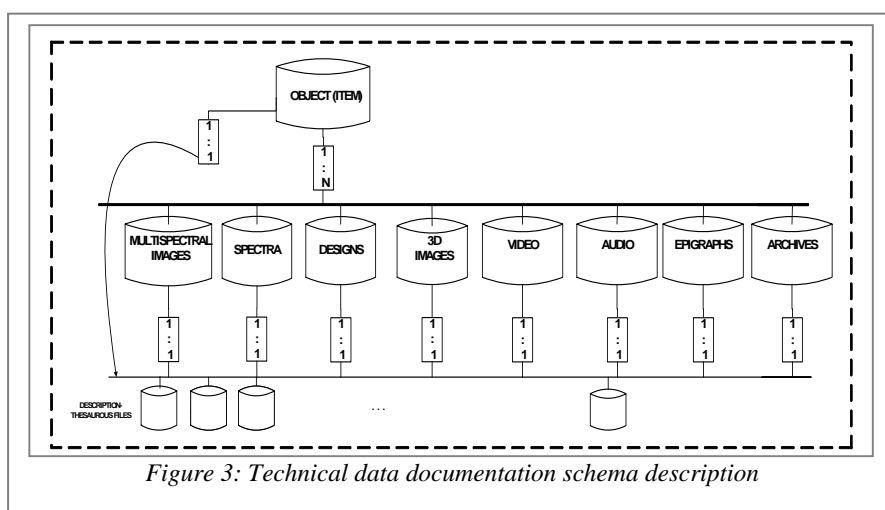
Diagnosis of artworks is a main part of the conservation science. Diagnosis - technical examination is the procedure that is applied

before the conservation treatment of the objects. The diagnosis - technical examination procedure reveals all the current state of preservation of the object providing the user with a rich knowledge background with plenty of multidimensional data and metadata [3]. There is a special relation between the meta-data, which reveals all the knowledge concerning the artwork, obtained from the diagnosis procedure.

The kind of the data that are produced within the work carried out in the museums conservation laboratories from the diagnosis procedure are:

1. Multispectral images in various spectral areas (UV, VIS, nIR, X-Ray etc), 2. Spectra (UV, VIS, nIR, etc), 3. Different kind of Measurements (eg. Provided by spectroscopy in the visible area of the spectrum, colorimetry, etc), 4. 3D geometry, 5. Epigraphs, 5. Designs, 6. Video, 7. Audio, 8. Text, 9. Bibliography.

All this kind of data are used in order to provide the user with well documented information concerning the state of preservation as well as the whole “adventure” [3] of the artwork during the past. “BYZANTIO” system unifies all the conservation science documentation in a common system and for all the kinds of the objects that belong to the collection. The object has a relation 1:N for each kind of the technical data (images, spectra, measurements, bibliographic search etc) which are stored in separate files [1] – tables as shown in figure 3.



2.3 Conservation treatment documentation.

One of the most important targets of the presented system is the documentation of the conservation treatment work that is being carried out in the conservation labs of the museum.

The way that the domain experts (conservators) treat the artwork and document their work is presented in order to better understand the way that this domain knowledge is implemented in the “BYZANTIO” system (The case is provided by the Icons

laboratory): The conservation treatment and its documentation is constituted by five main concepts: 1. Manufacture – Creation 2. Technology, 3. Pathology diagnosis, 4. Examination – study (diagnosis), 5. Specification of the maintenance condition and restoration, 6. Final result. The technology used for the creation as well as the state of preservation of the object are documented using several and complementary study methods well known as the diagnosis procedure of the object described in paragraph 2.2. The results of these methods are documented in “BYZANTIO” system and are used for the documentation of the conservation treatment designating mainly the methodology that will be used for the conservation treatment of the object. Since the technology used and as well as the current state of preservation of the object is revealed through the use of the diagnosis procedure then the examination of the object is performed aiming to the determination of the overall pathology and consequently of the conservation strategy and the final restoration that will be performed. An example is provided as follows:

The examination of an icon is performed bottom up from the lowest paint layer up to the upper paint layer. This approach is imposed by the specific construction of a portable icon: The examination procedure, that is the first level for the conservation procedure that will be followed, is leaded from the necessity of the study of the state of preservation and the stratigraphy in specific points on the icon. The role of the substrate, the preparation, the bole constitute a structure that ensures the good state of preservation of the overall substrate. This concrete, scientifically complete still complex structure is implemented in a user friendly way and for all the kind of objects of a museum collection in a common system.

2.4 User administration - user profiles support

The user belongs to laboratory and to a profile. The laboratory is categorised in relation to the objects of the collection so there are laboratories for:

1. Icons, 2. Ceramics, 3. Glass, 4. Manuscripts, 5. Wooden, 6. Paper, 7. Manuscripts, 8. Metallic, 9. Marbles, 10. Frescoes, 11. Stones, 12. Mosaics and other

The profiles of the users are categorised according the Museum hierarchy and operation resulting to different kind of access to the data and metadata:

1. Administrator, 2. Archaeologist, 3. Responsible conservator of the Laboratory, 4. Conservator, 5. User having access to the Inventory, 6. User and other.

According the Laboratory and the profile the user has customised access and rights to the database content. For example the responsible conservator of a laboratory has access and the rights to modify the cognitive models of the conservation treatment as well

as to insert and modify (as well as delete) the data of the conservation treatment of a specific object. The simple conservator has access only to navigate to the cognitive model as well as insert data to the conservation treatment of the object but not delete them or modify them after these are stored without authorization.

3. Semantic formalization of the conservation treatment of different kind of objects, implementation and database mapping

3.1 Cognitive modelling

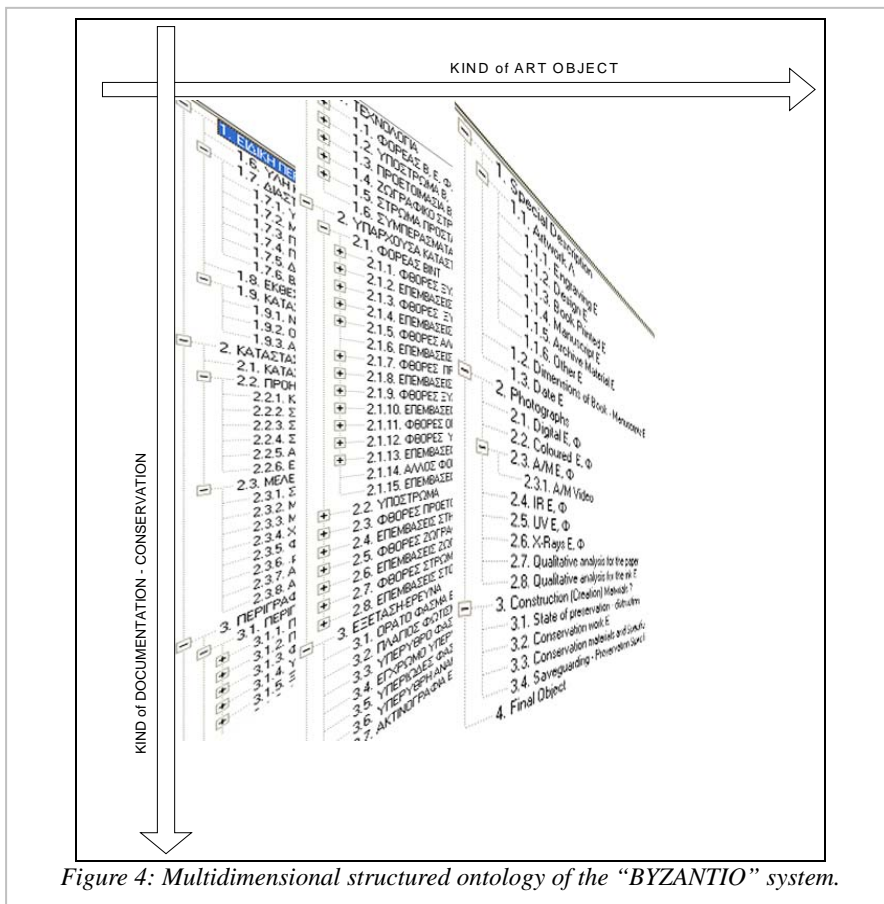
The documentation of the conservation treatment of different kind of objects within the Museum collection requires the need of the formalisation of different kind of knowledge depending mainly on the kind of the object. Within “BYZANTIO” system cognitive models semantically formalised were developed in order to provide the scientists with the possibility to document the conservation treatment of the different kind of objects. The cognitive modelling and the semantic formalization deals with textual material, organized under an ontology schema, taking into account the museum practice in accomplishing its cultural services. This is a "multidimensional" problem. One dimension is the type of the object and another is the kind of the documentation. The typology of objects include:

1. Icons, 2. Ceramics, 3. Glass, 4. Manuscripts, 5. Wooden, 6. Paper, 7. Manuscripts, 8. Metallic, 9. Marbles, 10. Frescoes, 11. Stones, 12. Mosaics and other and the kind of documentation could issue from: 1. Historical placement, 2. Aesthetic approach, 3. Descriptive analysis, 4. Conservation science, 5. Conservation treatment and other. Each kind of documentation is different for each type of object (figure 1). A possible and indicative part of the conservation treatment is structured as an ontology and mapped to a multimedia database of a collection of objects. The type of object is a painted icon artwork and the kind of documentation is the conservation treatment. The steps that “BYZANTIO” system guides the user for the cognitive model development are:

1st : The modeling of the class of the specific documentation treatment,
2nd : The determination of the level of the knowledge for each class (table 1)

The first two steps have as a result the structure of the conservation treatment strategy using cognitive models and semantic formalization. Then within the 3rd step the cognitive models are linked with the content that supports these structures and documents their knowledge (Digital data provided by the scientific examination). The cognitive models are based on concepts which in this case are: Manufacture – Creation Technology, Pathology diagnosis, Examination – study (diagnosis), Specification of the maintenance condition and restoration, Final result). For each

concept several levels of knowledge are broken down according the domain knowledge of the conservation treatment (table1). For each class and consequently each level of this cognitive model structure, there is a number of different kind of data that can be used in order to document the artwork.



So the final result will be a "multidimensional" structured ontology (figure 1), having the parameters of the different types of objects as well as the different kind of documentation. In figure 7 one can also observe the structured description of the ontology of several kinds of conservation treatment and objects' typology such as the painted icons described in table 1. Firstly the concepts are determined (for eg in this case: Manufacture Technology, Current State, Research – Study, Conservation – Restoration, Final Result) and then the levels of Knowledge for each concept (for eg. For level 1: Carrier, Substrate, Preparation, Paint Layers, Protection layers, Results – Observations et cetera as shown in table 1). Each level of knowledge is linked with the database using the appropriate kind of fields (described in paragraph 3.2). In table 1 the example for the painted icon conservation treatment cognitive structure is provided:

Table 1: Structure of the cognitive model of painted icons art objects

Classes		Levels of knowledge				
1.	Manufacture Technology	0			...	
1.1.	Carrier B, E, Φ , ΣX , E, BINT		1		...	
1.2.	Substrate B, Φ , E, ΣX , BINT		1		...	
1.3.	Preparation B, E, Φ , BINT, ΣX		1		...	
1.4.	Paint Layers Φ , BINT, ΣX , E		1		...	
1.5.	Protection layers E, Φ , BINT, ΣX		1		...	
1.6.	Results - Observations E		1		...	
2.	Current State	0			...	
2.1.	Carrier BINT		1		...	
2.2.	Substrate		1		...	
2.3.	Destructions on the preparation layer		1		...	
2.4.	Interventions to the preparation layer		1		...	
2.5.	Destructions to the paint layers		1		...	
2.6.	Interventions to the paint layers		1		...	
2.7.	Destructions to the protection layers		1		...	
2.8.	Interventions to the protection layers		1		...	
3.	Research - Study	0			...	
3.1.	Spectrum in the Visible E, Φ		1		...	
3.2.	Raking Light E, Φ		1		...	
3.3.	Infrared Spectrum E, Φ		1		...	
3.4.	Coloured Infrared Spectrum E, Φ		1		...	
3.5.	Ultraviolet spectrum E, Φ		1		...	
3.6.	Infrared reflectoscopy - Multispectral imaging E, Φ		1		...	
3.7.	X - Radiography E, Φ		1		...	
3.8.	Cross sections E, Φ		1		...	
3.9.	Microscopy E, Φ		1		...	
3.10.	Absorption IR spectroscopy E, ΣHM , E, Φ		1		...	
3.11.	Gas Chromatography E, ΣHM		1		...	
3.12.	Mass spectrometry E, ΣHM		1		...	
3.13.	RAMAN E, ΣHM		1		...	
3.14.	LIF E, ΣHM		1		...	
3.15.	LIBS E ΣHM		1		...	
4.	Conservation - Restoration	0			...	
4.1.	Disinsection B		1		...	

4.2.	Consolidation		1		...	
4.3.	Cleaning		1		...	
4.4.	Interventions		1		...	
4.5.	Protection Layer		1		...	
4.6.	Restoration		1		...	
5.	Final Result Φ	0			...	

3.2 Implementation using an authoring interface

The user expert creates the cognitive model structure in order to describe the documentation of the conservation treatment of the object. The structure is created according the conservation procedure. Then the concepts and the levels of knowledge are structured. The connection of this knowledge description through the structures encoding (semantic formalisation) with the database of the data and metadata of the scientific examination is performed (DB mapping). This leads the system to the cognitive model since from one point a structured description and encoding of the conservation science field and application is performed and the connection with the real knowledge (study of the artworks) from the other is applied.



So not only description of the cognitive model is applied but the mapping of the data supporting these structures is also performed by the user. A graphical representation of the mapping procedure is shown in figure 5. For each level of knowledge (concepts) the kind and the number of the fields in which the data of the database will

be retrieved are determined linked with the corresponding tables of the database. The authoring tool that is used by the user in order to implement the above described actions has the following features:

- Graphical interface for managing and navigating the multimedia database. This interface is developed with rapid development tools providing XML possibilities for export of the data and the data structures (OMNIS STUDIO or even ORACLE interface tools with Java).

- Provide the possibility to implement the cognitive models and store the models in the database in order that the terms used for each level of the structures (cognitive models) to be indexed with thesaurus files.

- Provide the possibility to make the link of each level of the models to the multimedia databases in order to document the cognitive model with the real technical and historical data automatically retrieved. This relation of the cognitive models with the databases will help the comprehensible retrieval of the technical information (or in general of the multimedia information) from the database through the use of the cognitive models in order to display this. The user has to open the conservation treatment related form in which general fields concerning the necessity of restoration action that should be performed for the specific art object are filled. From this form there is a link to the technical documentation data in order to handle these data supporting the conservation treatment documentation as well as a link to the determined cognitive model structure of the conservation treatment. The procedure how the user determines the conservation treatment structure is described briefly as a paradigm:

The user chooses to open the tool with which he will create the structure (ontology) as well as he will map this structure to the database (figure 2). Using the buttons that appear in the bottom of the form in figure 2, the user can create the whole structure. Using the first button the concept is created for example “4. Conservation – Restoration” which appears in the right part of the form in figure 3. Then by pressing the second button, the levels of knowledge are structured for each concept for example: Concept “4. Conservation – Restoration” -> “4.6 Restoration” and so on creates all the structure of the conservation treatment documentation (cognitive models semantically formalized). After the implementation of the cognitive model and semantic formalization, the expert – user, for each level of knowledge determines the kind of data linked with the database, containing the multimedia content provided by the scientific and technical examination (database mapping) according the general concept of the support of all the documentation by the technical examination (multispectral imaging, spectroscopic and micro-analytical data).

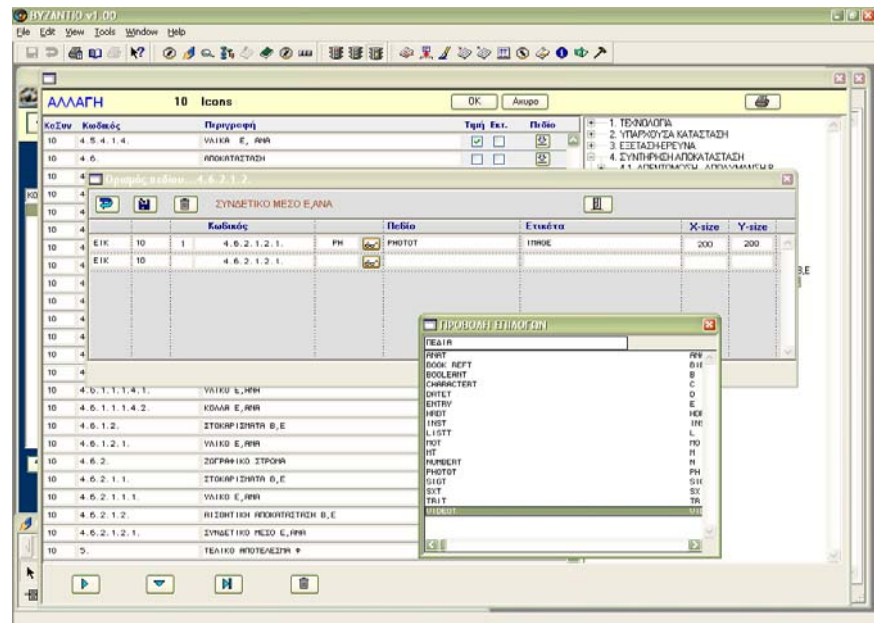


Figure 6: Definition of the structure off the conservation treatment documentation. Determination of the kind and the type of the fields in the structure (DB mapping). Insert and update of the fields for each level of the cognitive model. Determination of the field for each level of the cognitive models

By pressing the button with the arrow the database mapping procedure takes place. The forms appearing in figure 3 are opened providing the user with the possibility to define or update the number and the kind of the fields that will be stored for this branch of the structure. The user can choose the fields that will be used in this level as well as their graphical appearance providing the coordinates and the size of them (figure 6).

4. Case study

Some screenshots of already existing records in the system are provided in the following figures:

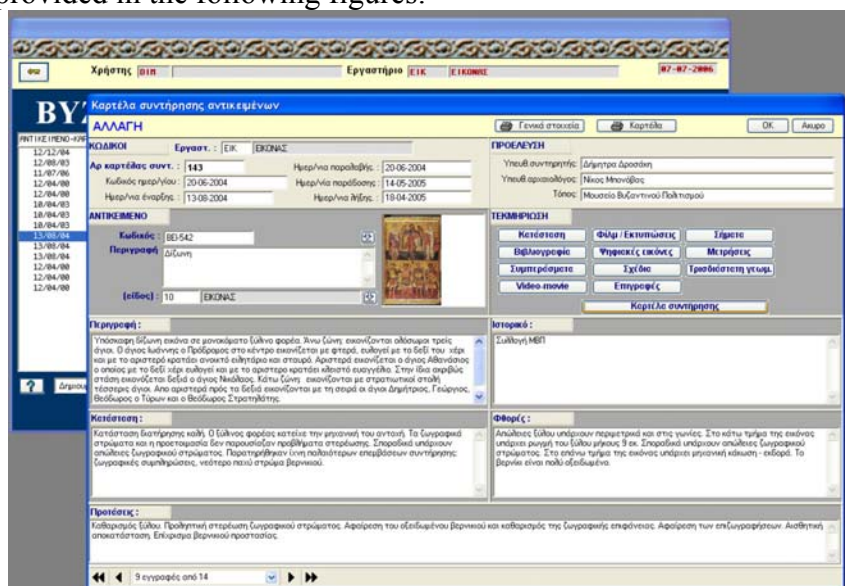


Figure 7: General data sorted concerning the conservation treatment of the object.

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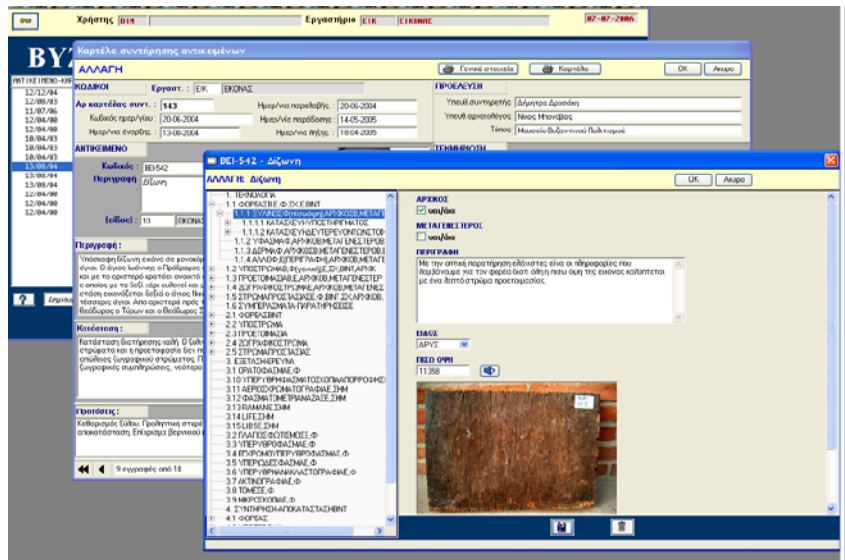


Figure 8: Detailed description of the conservation treatment of a Byzantine icon using the corresponding cognitive model defined in the system. Retrieve of the data using the cognitive model from the linked database (Conservation of a Byzantine icon->1. Technology ->1.1 Substrate ->1.1.1 Woden (back side)).

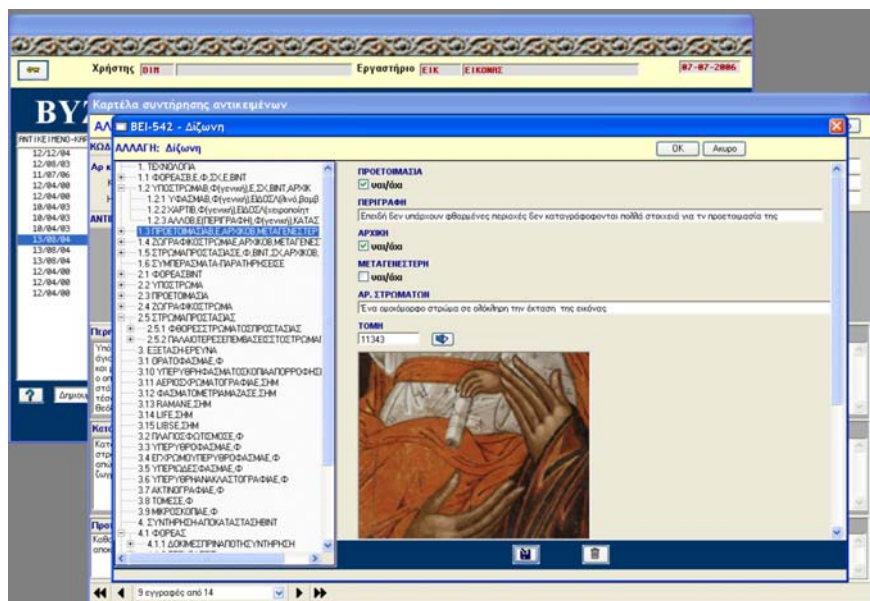


Figure 9: Detailed description of the conservation treatment of a Byzantine icon using the corresponding cognitive model defined in the system. Retrieve of the data using the cognitive model from the linked database. (Conservation of a Byzantine icon->1. Technology ->1.3 Preparation).

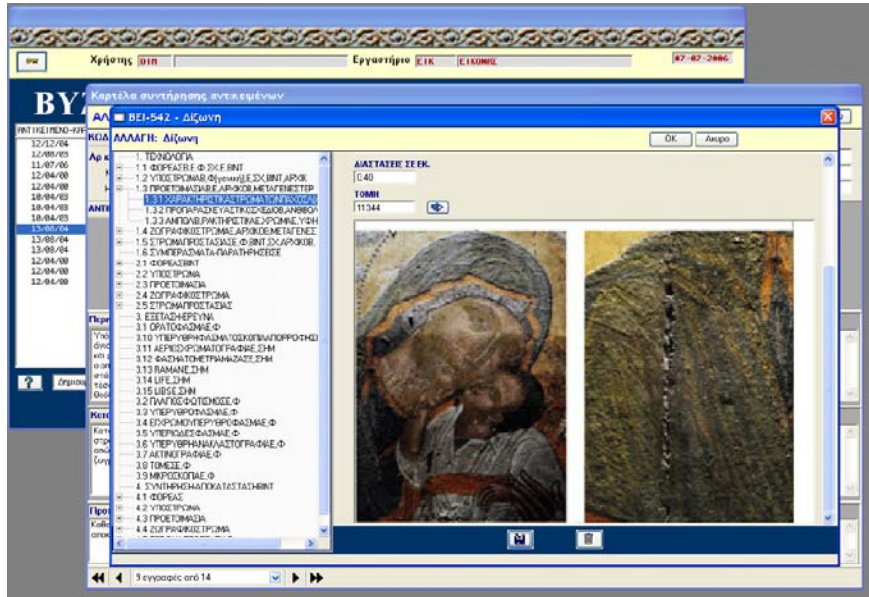


Figure 10: Detailed description of the conservation treatment of a Byzantine icon using the corresponding cognitive model defined in the system. Retrieve of the data using the cognitive model from the linked database.
(Conservation of a Byzantine icon->1. Technology ->1.3 Preparation -> 1.3.1 Layers).

5. Technical Characteristics in Brief

In brief the technical characteristics of the system are:

- Open architecture
- Developed with rapid application tools and 4GL Languages
- Connection with other applications with ODBC, JDBC
- Supports Adhoc printouts
- Operation via TCP/IP networks
- Compatible with:
 - WINDOWS, MAC OS X, LINUX
- Description of the Meta data using XML.
- Compatible with
 - ORACLE (recommended), SQL Server and other
- Provides the user with SQL interface
- The DIGIMARC image watermarking is also used by the system.
- Unlimited data storage

«BYZANTIO» system is fully parameterised constituting the kernel for the development a concrete infrastructure for setup of an artworks documentation tool within a Museum operation (artworks management, scientific documentation, conservation, exploitation). «BYZANTIO» is compatible with the existing standards of documentation of cultural heritage objects so every adjustment towards this important direction is ensured with low cost and low time reaction.

6. Conclusions

6.1 Contribution to standards

The implemented structures of the conservation treatment (ontology and database mapping) can be proposed as supplementary information to the international standard of CIDOC-CRM ISO. The domain ontology for the conservation treatment will lead the user conservators of the system to assimilate the conservation strategy that is followed for each object. In general we can conclude that the «BYZANTIO» authoring interface and database implementation proposes and provides the scientific community with:

- A common structure for the conservation documentation that has not been implemented up to now in an operational system providing the user – conservator with a electronic tool to document the conservation strategy that he followed always in the frame of the general structure that is determined using the authoring interface. The proposed structures included in the system can constitute a concrete proposition of the MBCTh to the CIDOC system.
 - Within this structure a first time data and database structure is implemented and proposed for the documentation of the conservation science outcome.
 - The description of this structure using the authoring interface provides access to conservation science data and strategies facilitating the navigation and retrieval of the content using semantic concepts that for a first time are stated.
 - A database and authoring interface tool for the Archaeologists, Art Historians, Conservators for the description of their scientific work achieving the safeguarding of the scientific work carried out in the Museum still reusing this work for the dissemination and education of all the concerned users (scientists, conservators, visitors in the future)
 - A simultaneous access to the rich content of a Museum collection using different points of view (disciplines) so that all the users (art historians, archaeologists, conservators) and in different “depth of knowledge”-levels in the defined structures (ontologies) in the system aiming in the multidisciplinary documentation of the objects.

Taking into consideration that for the creation of this tool engineers, conservators, archaeologists and historians have collaborated, some open issues revealed:

Proposition of common and relevant terms for several levels of the conservation science contribution to the documentation of artworks always targeting to operational informational systems. At this stage, the terms alone represented the concept, concealing significant ambiguities and differences of opinion. A clear issue that arose is the terminology differences among different artworks and between the different kinds of documentations. The classes and

the levels of knowledge were decided based on then study that the conservators of the Museum have performed. Most of the important concepts and many terms were identified (paragraph 3). The main work of building the ontology was then to produce the level of knowledge and the corresponding definitions as well as the link with the database.

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