An Electronic Sales Infrastructure for the Exploitation of Digital Cultural Heritage and Copyright Protection of Digital Images

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Abstract-- **This paper focuses on the design and implementation of an Electronic Sales Infrastructure for Digital Images of the Cultural Heritage. The main components of the infrastructure are an Advanced Digital Image Repository, which offers specialized services and a Dedicated User Interface for the protection and management of the Intellectual Property Rights of digitized material. In addition, another main research area of this contribution is the design and implementation of an Electronic Sales System, supported by advanced technologies, for the proper exploitation of the digital cultural content. The work described in this contribution focuses on digitized material of the Hellenic Cultural Heritage. It has been carried out as part of the PRAXITELIS Project, which was originally presented during the Culture Track of the WWW9 Conference in Amsterdam ([8], [9], [10]). This project is focusing on countering "electronic theft" and protecting the copyright of digital surrogates of photographs of artifacts, monuments and sites.**

I. INTRODUCTION

T HE great value of cultural content is by now well recognized as it relates directly not only to culture in general but to important and vast markets, mainly Education, Tourism, Entertainment and Research. While network access and fast and easy delivery of digitized cultural material, such as digital surrogates of artifacts, monuments, sites, museums, various types of collections and so on, is of outmost importance for content owners and users as well. At the same time, wide access and delivery of valuable content raise several critical issues, pertaining to management, protection and exploitation of digitized cultural content. Reasons that prevent the commercial exploitation of cultural digital objects include:

- The critical problem of IPR (Intellectual Property Rights) protection, especially in wide area networks (Internet)

- Unauthorized use and exploitation of digital data ("electronic theft") and inefficient protection measures.
- The, under definition, national pricing policy for cultural digital objects of many European Nations, especially for commercial transactions over wide area networks.
- Weak national legislation of many European countries, especially on the issues of Intellectual Property in the digital age, Copyright, rights for traditional or electronic Publications, rights for electronic Distribution, legal means of protection and legal proceedings against "electronic theft".

Besides economical and other implications, such problems create considerable skepticism to cultural organizations and individual content owners. As a result content of great educational and economical value is often held secret and private.

The main issue addressed in this paper, apart from studying the above critical problems, is to propose concrete solutions. More specifically the solutions proposed are:

- An integrated large-scale information system for the management, protection and exploitation of cultural digital images. This system is under deployment and its main features have been presented originally in the WWW 9 Conference in Amsterdam and in various other conferences. Except for the management of the digital objects, the main purpose of the information system is to study, evaluate and develop methods and applications of protection for the digital objects and the Intellectual Property Rights. New applications are being developed, which take into account technologies like watermarking, metadata, encryption, unique identification and interoperability, in the World Wide Web
- The establishment of a working group, supervised by the Hellenic Ministry of Culture, for the planning of the national pricing policy, especially for cultural digital images of the Hellenic Cultural Heritage that are being economically exploited over wide area networks and CD-ROMs. Exploitation of the results of the information system and of the council for the enforcement of national legislation regarding Intellectual Property in the information age.

The next chapters are presenting the general system

architecture and its main components, which are:

- An Advanced Digital Image Repository. The fields and tables are selected in accordance to international metadata standards.
- A Dedicated User Interface, which protects digital content with watermarking techniques.
- An Electronic Sales System that incorporates a Web Based Library.

II. ADVANCED DIGITAL IMAGE REPOSITORY

The design and implementation of the Advanced Digital Image Repository for this information system is a very important task. A repository fully capable to serve as a platform to this system should incorporate the following basic characteristics:

- Scalable. That is, the capability of gradually improving its performance in accordance to the platform and the number of computing resources used. The information system is a distributed one. Independent repositories already exist throughout Greece and are installed in the Ephorates and other authoritative Agencies of the Hellenic Ministry of Culture. The integration of these independent installations requires a scalable and modular repository.
- Support for multimedia and advanced hypermedia applications for digital image, audio, animation and video.
- Internet oriented, providing secure and easy access to data and metadata via the Internet and corporate Intranets. The Hellenic Ministry of Culture already has a corporate Intranet (designed and implemented by the High Performance Information Systems Laboratory) and, as a result, the integration of the digital repository to this already existing infrastructure is considered necessary.
- Support for applications and interfaces for data and metadata manipulation. These applications do not only include the built-in mechanisms of the database management system, but also user interfaces developed and customized in a way that they meet the needs and requirements of this project.
- Usability and effective management. Ease of implementation, configuration and usage. Open to programmers and developers for its customization.
- Global access from distributed locations, supported by technologies for protected transactions and data transfer, replication and backing-up, data encryption and decryption.
- Open to new technologies and programming languages like JAVA and XML.
- Scheduled synchronization of distributed database instances in a national network of Digital Image Repositories. The central Advanced Digital Image Repository is being deployed in the premises of the Hellenic Ministry of Culture. Other databases will be distributed locally all over Greece, especially to locations of major cultural importance.

Except from these basic characteristics, metadata for digital images, unique identifiers and watermarking methods are embedded into the Advanced Digital Image Repository. The Advanced Digital Image Repository is implemented using the IBM DB2 Universal Database (Version 7.1, Fix Pack 3) with the AIV (Audio, Image and Video) and XML Extenders [12].

III. SELECTION OF METADATA FOR DIGITAL IMAGES AND IPR MANAGEMENT

The specific tables and fields, which are used for the repository of the digital images, were selected in the basis of the next requirements:

- The user requirements generated from the Hellenic Ministry of Culture.
- The international standards for describing, characterizing and identifying digital objects.
- The international standards for managing and protecting the Intellectual Property Rights.

The need of adopting the international standards is essential, especially for applications aiming cultural content exchange and on-line payment. Following these guidelines, the result is an open information system ready to be integrated into an expanding global, multi-language and multi-national network were the digital objects and the metadata coupled with them are uniquely identifiable and interchangeable.

The DIG 35 Specification "Metadata for Digital Images", Version 1.1 [3] has a very important role in this selection of fields and tables, as far as the metadata for the digital images are concerned. This metadata standard is already being widely used from simple end-user devices to worldwide networks. The database structure has a special focus on metadata for the Intellectual Property Rights management. A simplified description of the database structure already implemented follows.

Basic Metadata Table of the Digital Image

This table includes the following fields, which point to other relevant tables:

- Digital Image ID number (unique identifier).
- Basic Image Parameter.
- Image Creation Metadata and Image Description Metadata.
- History Metadata and IPR Metadata.

Basic Image Parameter

A simplified description of the structure of this table is presented below.

Image Creation Metadata

The image creation metadata include fields ranging from the general information of the creation of the image to specific information about the camera or the scanner used during the creation of the image. More specifically:

- Fields for the general information of creation.
- The Camera Capture field incorporating the fields:
  - Camera Information.
  - Software Information.

- o Flash Information.
- o Camera Settings.
- The Scanner Capture field incorporating the fields:
  - o Scanner Information.
  - o Software Information.
  - o Scanner Settings.
- The Captured Item field, which contains information about the object that is captured by the device (like a film or a reflection print or even a computer-generated item).

This table includes the following fields, which point to other relevant tables:

- Group Caption.
- Capture Date and Time.
- Location.
- Person Description.
- Thing and Organization Description.
- Event.
- Sound.
- Dictionary Definitions.

Image Description Metadata
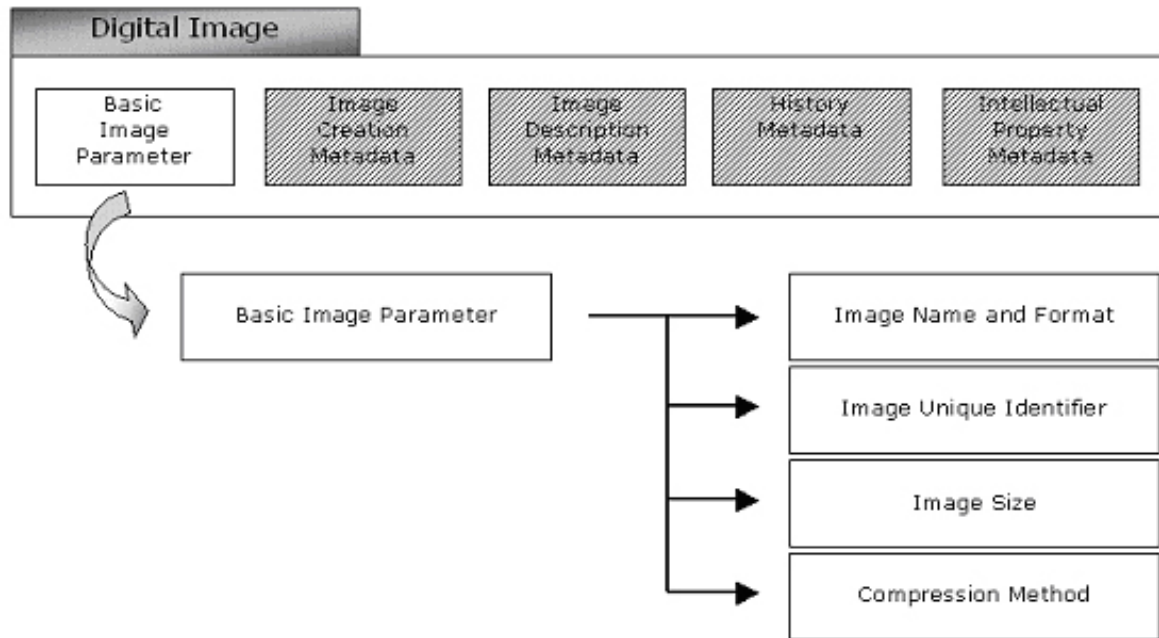
Basic Image Parameter Table

History Metadata

The table of History Metadata contains information about the history of the image processing. It includes the following fields:

- The processing summary of the image, describing processes such as rotation, compression, cropping and histogram modification.
- The history of the image metadata.

IPR Metadata

This table could be characterized as the lifeblood of the information system in the terms of Intellectual Property Rights protection and management.

IV. DEDICATED USER INTERFACE

The Dedicated User Interface is the tool for the archaeologist or staff of the authoritative agencies of the Hellenic Ministry of Culture (HMC). Allowing the distributed management of digital images, it serves specific functions and transparently to the user embeds watermarks into the pictorial representation of objects of the Hellenic Cultural Heritage.

This is the client that is going to be installed inside agencies all over Greece and will connect to the central Advanced Image Repository located in the premises of the HMC. This chapter presents the functions of the Watermarking Environment. The basic features of the Watermarking Environment are already implemented and all its advanced features are expected to be implemented by June 2001.

A. Principles of Implementation

The main objective of this system, from the start, was not only the image management functions but also the implementation of advanced services for searching these images. For example, an advanced service is searching for a digital image based on its content, color, histogram and shape. For this reason the selected database system is IBM DB2 Universal Database 7.1 [12] and the selected GUI development tool is Microsoft Visual Basic 6.0. Custom-developed dynamic libraries (DLLs) are extensively used for the interconnection of the GUI with the database system.
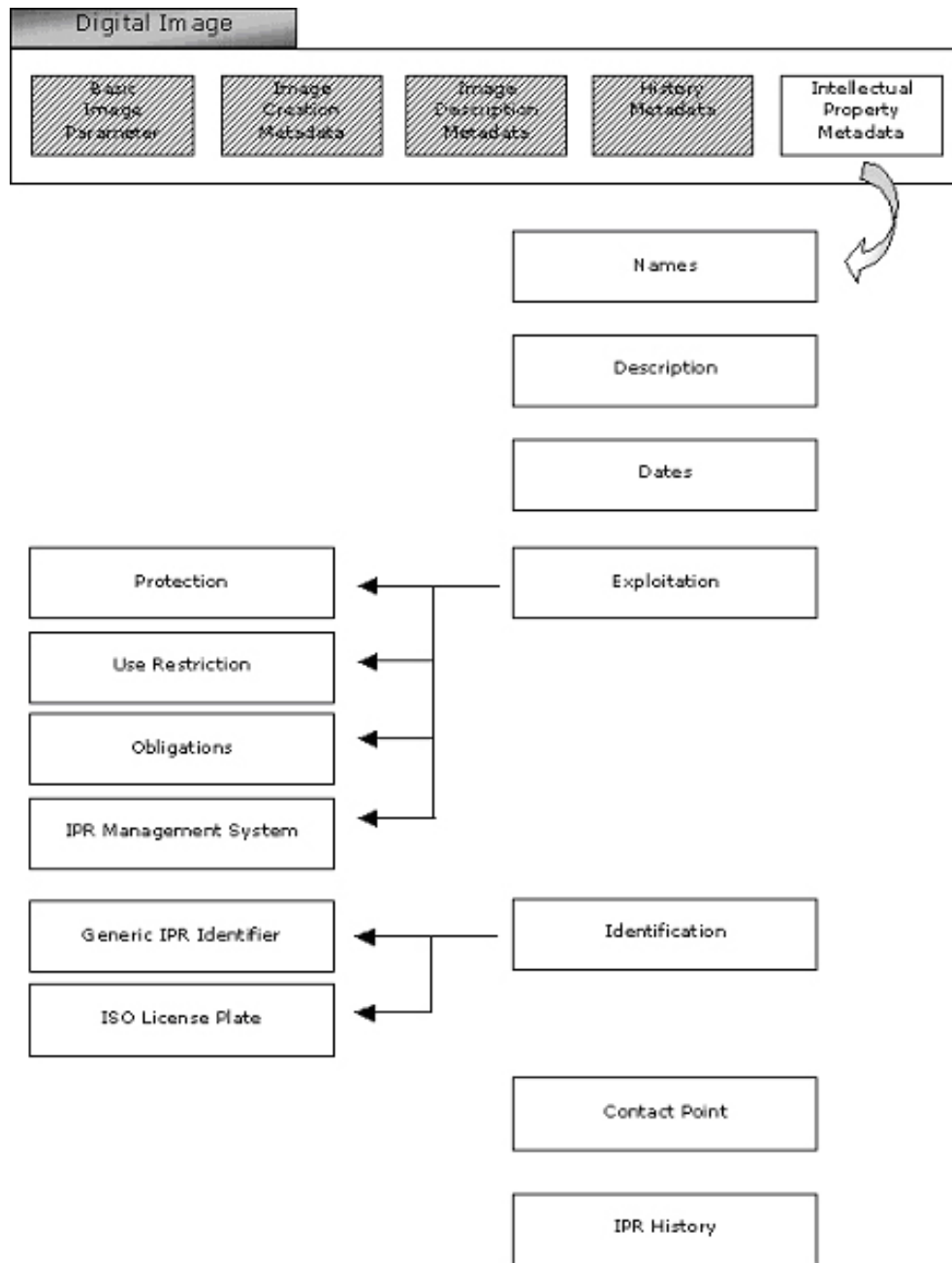
Intellectual Property Metadata Table

B. Transparent Functions

Watermarking: Invisible watermarks are the proposed solution for the protection of Intellectual Property Rights and for dealing with the problem of illegal reproduction of multimedia objects [4], [6], [11]. Numerous watermarking schemes have been proposed and evaluated and the performance evaluation has resulted in the selection of the best watermarking tools for this information system [7]. These tools have been obtained in SDK (Software Development Kit) format and are being embedded in the Digital Image Repository using technologies that the database management system provides. The goal is the watermarks to be embedded in the digital images when the digital image is being stored in the central repository, automatically. This general strategic planning is focusing on:

- Distributed management of the watermarking process and scheduled synchronization of the regional databases. The watermarks should be embedded in the digital image wherever a database exists and then the images should be transferred to the central Advanced Digital Image Repository in the premises of the Hellenic Ministry of Culture.

- The watermarks should be embedded only into the high quality digital surrogates of objects of the Hellenic Cultural Heritage.

- The watermarks should carry two ID numbers. The first number, will be common to all digital images, and will identify the Hellenic Ministry of Culture as the copyright holder of the digital image being processed. The second number will identify the instance of the transaction, containing the digital image and the persons that are involved to that transaction. This number is a reference that points to specific IPR related information in the database. This information is stored in the table described above, which relates to the IPR metadata.
- The watermark should be robust to attacks and detectable over Internet oriented environments. This is ensured in the basis of the exhaustive evaluation, which has been conducted [7].

This watermarking schema is being implemented via the creation of Dynamic Link Libraries (DLLs) that are available with the Dedicated User Interface.

The watermark is embedded transparently into the digital image. An insertion of a digital surrogate into the central database causes the inevitable embedding of the appropriate digital watermark. This function is incorporated into the client, not the server, and is implemented on Microsoft Windows Operating Systems. This was chosen mainly for three reasons:

- The installment of the central Digital Image Repository is independent from the operating system and platform. The client is remotely connected to the central Digital Image Repository.
- The Microsoft Windows operating system provides for efficient communication with scanners and digitization tools and is the standard operating system for the Authoritative Agencies all over Greece.
- The watermarking software (and its SDK) is Win32 based.

The implementation method is based on the creation of a dynamic library (DLL) that is referenced from the Watermarking Environment and holds all the necessary functions for the Watermark embedding and detection. The computer language for the implementation is C++.

Database Connection: Whenever a user is using the Watermarking Environment, a permanent connection exists, between the client and the central Digital Image Repository. This connection is established during the user authentication and is preserved until the user exits from the client.

Disconnect: When the user exits, certain steps are applied for the appropriate disconnection of the client from the database.

The connection and disconnection procedures are part of a custom library (DLL) that serves for special functions such as user authentication, data logging, etc.

C. Image and Metadata Management Functions

The functions that are already implemented include basic image management procedures. A part of the basic image management functions are implemented by dynamic link libraries in Microsoft Visual C++ and the other part using Microsoft Visual Basic.

The dynamic link libraries submit SQL instructions to the central Digital Image Repository and consist of the following basic functions:

- Connect and Disconnect (previously described).
- Retrieve and Import.
- Search using:
  - a watermark
  - a unique identifier
  - similarity criteria (color, histogram, shape, etc.)

The rest of the functions, mainly consisting of image scanning, caching and printing, are implemented using the Microsoft Visual Basic Form Controls, the Microsoft Web Browser Control, the Kodak Imaging Controls and the ADO Data Binding Control. In addition, image insertion can be done directly from a TWAIN source (such as a scanner or a digital camera) or from external files.

The application under development creates XML documents containing information from the advanced digital image repository. For this project the usage of XML [15] is recommended as the standard metadata interchange format [9]. The primary reasons are, XML is widely adopted as an Internet-based language. XML is highly extensible and device independent. In addition, XML is language and application independent. The XML documents are produced by user-defined SQL queries. The XML documents are based on an XML schema, which derives from the XML schema of the DIG35 Metadata Standard. The XML schema is modified in accordance to the specifications of the Hellenic Ministry of Culture. The output files are automatically populated with XML Template Files. These template files interconnect the database schema and the XML schema. The presentation of the results is accomplished through the transformation of XML files to HTML, using Microsoft XSLT Processor or the IBM XML Lightweight Extractor (XLE) [16].

V. INDICATIVE SCENARIO

The main purpose of the indicative scenario is to present an overview of the system's everyday use. It is assumed that:

- Training of the necessary personnel of the authoritative agencies of the HMC is completed successfully.
- The system is installed in three selected organizations supervised by the HMC.
- Certain time for adjustment and performance optimization has passed.

In everyday use the system supports:

- The distributed and simultaneous insertion, deletion and management of digital surrogates in the selected organizations.
- Automated and imperceptible embedment of watermarks for the copyright protection of the digital content. The copyright notice "COPYRIGHT HMC" is incorporated in the images as a watermark.
- The insertion of more than twenty high quality digital images per day and per organization.

- The overall daily number of digital images is sixty.
- Once a month and when the HMC's network is not overloaded, these digital images are safely transferred through the network to the central database server.
- Low quality, watermarked copies are automatically presented through the "PRAXITELIS" Web Site. The Internet user is able to query the database by image content and layout.

The above scenario is based on the assumption that a trained user in every organization will be using the system five hours per day.

VI. ELECTRONIC SALES SYSTEM

The system aims at establishing new standards in the field of e-commerce mainly in the cultural digital content in Greece. The most important research areas are:
- National and International pricing policies for digital images.
- Study of National and International legislation for the copyright protection of the digital content being purchased via the Internet.
- Proposal of a flexible on-line license agreement for the protection of Intellectual Property Rights of the digital content. Restrictions of use, rights for personal use should be defined.
- Proposal of a standardized pricing policy specifically for the digital images of the Hellenic Cultural Heritage.
- Design and implementation of an on-line shop based on heterogeneous databases with an advanced on-line catalog.
- Methods of secure commercial transactions.

The national pricing policy and legislation is supported by the establishment of a working group, supervised by the Hellenic Ministry of Culture (HMC), for cultural digital images that are being economically exploited over wide area networks and CD-ROMs. This working group – council has already contributed to pricing, licensing and protection of the use of images of archaeological content in the Internet. The members that compose this council are representatives from:
- Agency of the Hellenic Ministry of Culture for the Prehistoric and Classical Archaeological Monuments and Sites.
- Agency of the Hellenic Ministry of Culture for the Byzantine and post-Byzantine Monuments.
- The Archaeological Receipts Fund, which is the organization that defines the pricing policy of the HMC for different types of cultural goods.
- The Greek Organization of Intellectual Property.
- The Internet Office of the Hellenic Ministry of Culture, which is represented by researchers from the High Performance Information Systems Laboratory.

The undergoing process has produced a pricing policy for digital images purchased through the web. This policy is promoting a flexible user license agreement ("signed" on-line). The users that adhere to the terms of the license have the right to reproduce a digital image, to use the digital image in web sites, CD-ROMs, to edit the image and create original works, but do not have the exclusive rights to resell the digital image or indirectly gain profit based on the digital image. The pricing policy is depending on the digital image quality, size and content and could be summarized in the next table.

QUALITY	FILE SIZE	PIXELS	MAXIMUM SIZE	PRICE
Low	**2 MB**	**1024 X 1280**	**14,2" X 17,8"** **72 ppi**	**€30**
High	**14 MB**	**1700 X 2550**	**5.7" X 8.5"** **300 ppi**	**€120**
Very high	**32 MB**	**2800 X 4200**	**9.3" X 14"** **300 ppi**	**€200**

The digital images are provided to the user through the Internet and the estimated time to download is shown in the table below:

FILE SIZE	COMPRESSED FILE	28,8	56K	ISDN	T1
2 MB	**100 – 700 KB**	**5 – 7 min**	**1 – 2 min**	**< 1 min**	**<1 min**
14 MB	**1 – 3 MB**	**10 – 25 min**	**5 – 15 min**	**< 5 min**	**< 2 min**
32 MB	**2 – 5 MB**	**20 – 40 min**	**10 – 20 min**	**< 10 min**	**< 5 min**

The electronic sales system is under implementation. The general architecture is consisting of:

- The backbone of the architecture is the already implemented information system of "PRAXITELIS".
- The e-commerce server will be a platform located into the central offices of the Hellenic Ministry of Culture.
- The user will be using a Web Based Library as an on-line catalog. The Web Based Library is already implemented and is presented in the following paragraph.

- The digital images purchased through the Internet will be watermarked. This service is already implemented and should be incorporated in the electronic sales system.
- Strict security during the transaction and the transfer of critical information (Visa numbers, ids, etc.).
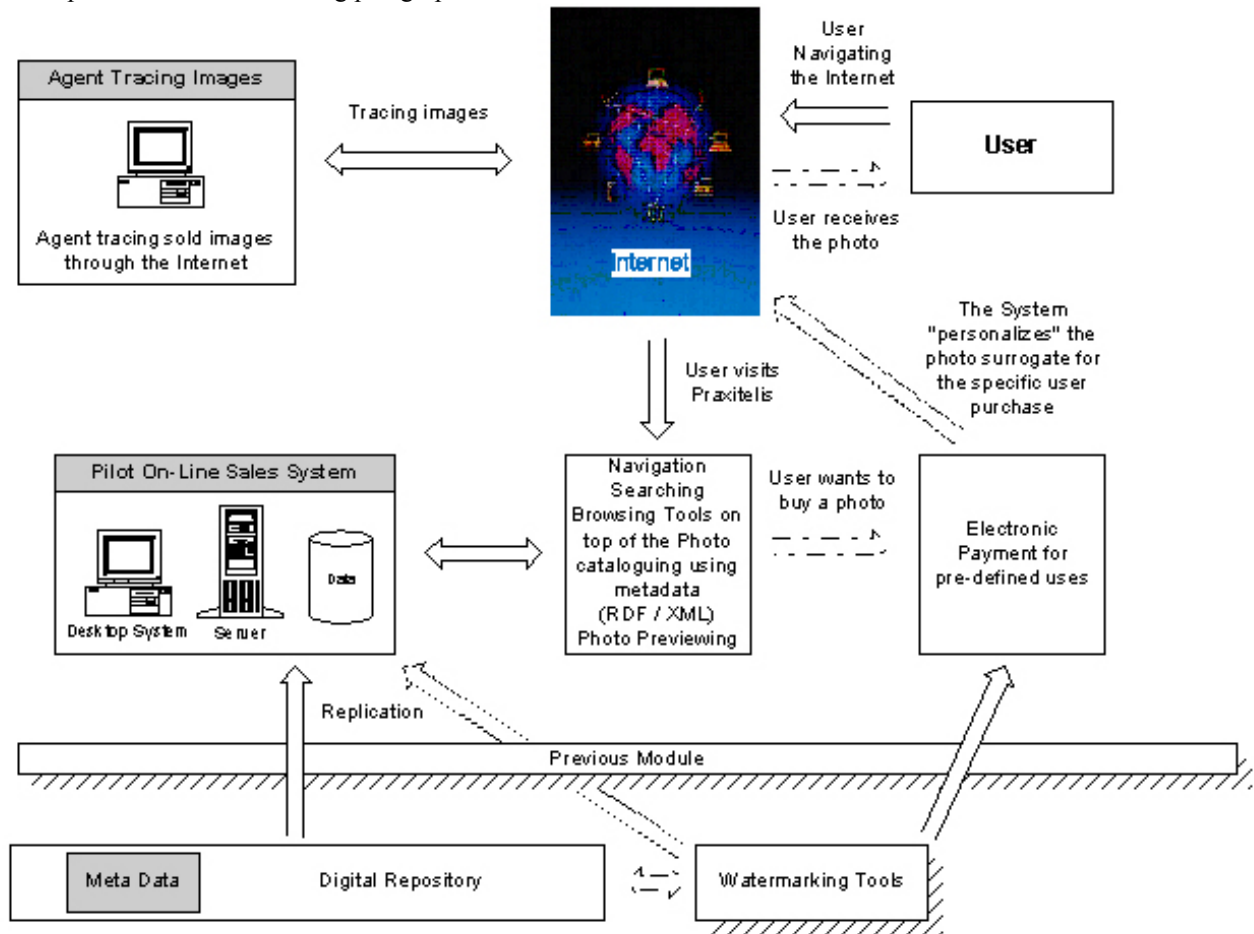
VII. PURCHASING OF DIGITAL IMAGES

Purchasing digital images over the web is a process that involves various functions and mechanisms. The most important are shown bellow:

- The standard basket mechanism for the collection of the images to be purchased.
- Checkout mechanism:
  - Through a secure (SSL) server.
  - Connection to credit card authorization on-line.
  - User profile for addresses and sensitive data (visa number) stored in secure database.

- Transaction mechanism.
  - Keep log of all transactions.
  - Watermarked images whit transaction ID. Traceable usage of the images over the web.
  - The metadata set of the Advanced Digital Image Repository will be extended to incorporate electronic sales transaction information.
  - The watermarking architecture will be augmented to support the insertion of a second signature, unique for every digital image transaction.
  - This transaction identification number will be the basis of the electronic sales system for digital surrogates of artifacts and monuments of the Hellenic Cultural Heritage.

The system under implementation will incorporate all the above components. In addition the user will have the ability to search the multimedia content in innovative ways provided by the Web Based Image Library.

VIII.   WEB BASED IMAGE LIBRARY

The Web Based Image Library is structured upon a Digital Image Repository and is used as the on-line searchable catalog for the electronic sales system. This digital image library is not only the gate of the information system to the world, but also provides numerous basic and advanced services. The basic features include:

- News and announcements dynamically exported by the announcements database of the Hellenic Ministry of Culture (HMC). This MS-Access database is maintained by trained staff of the HMC and collects all the news and announcements of the authoritative agencies of the ministry.
- Information and helpful documents.
- Online help that depends on the web page the user is exploring. The online help ranges from simple text to animated examples of how the system works.
- Except for the basic features the advanced web based digital image library implements advanced services for the user. These services include:
- Registration forms collecting user data that are stored directly to the Digital Image Repository. This data will be the basis for statistics and reports and the future extensions of the system.
- Advanced methods for searching the digital multimedia content. The search methods consist of:
  - o Search for metadata and free text. The user is expected to fill the required fields. The fields are referencing specific database columns and produce dynamic web pages. The user is able to search the database using relational constraints (AND, OR) and free text queries.
  - o Query by Image Content (QBIC). This advanced feature allows the user to send a query to the database in terms of color and/or layout. The layout search provides for queries that are created by the user and represent basic shapes (circles, rectangular,...) filled with the preferred color. For example a user could search for an image shaped like a yellow disc and the query will result to several images representing the sun.
  - o Zoom-in collections are those that give the flexibility to the Internet user to zoom in certain images. These collections are firstly presented by zoom-able thumbnails and some basic information.
  - o Copyright notices and protection. The digital images are protected by digital watermarks that identify the HMC as the copyright holder of the digital content.
- A thematic based catalogue that organizes the digital content in categories. The user is able to refine his search using the content categories.
- Collections and Selected Cultural Presentations. Selected digital collections are created and enriched with accompanying information. They refer to specific cultural topics of common national and international interest.

A.   Implementation Principles

The most advanced web technologies were exhaustively tested and evaluated. The largest part of the web site interface is built on pure web technologies, avoiding impressive but high bandwidth technologies like Flash or Quick Time VR. The principles of human computer interaction and usability were taken under high consideration.

Dynamic web pages, for the search results, are created with PHP. The descriptive pages of the artifacts (containing a large image and detailed information) are created using Java technologies implemented as UDF functions in the database. The news pages are generated, managed and updated using JSP and Java technologies, powered by an Application Server. Zoom in collections are presented through Java applets.

The database repository of the digital images and their metadata is implemented using the IBM DB2 Universal Database, with the assistance of the IBM DB2 XML and AIV Extenders. The system provides support for the streamlined implementation of the aforementioned XML schema and the advanced services for searching and retrieving digital images. QBIC searches are created by Java applets with the support with the AIV extenders.

All the above implementation decisions were taken after a thorough evaluation of the technologies that could be used for each case. A special consideration was taken for the decision of the use of Dynamic Pages (generated on the fly each time the user asks for them) and Static Pages Dynamically Generated (when data are added or updated). A very important factor in the technologies evaluation was the interoperability, scalability and security of the end product (at least at the server side).

B.   Implementation Paradigm

The Query by Image Content search engine is an advanced feature that allows the user to explore new ways of accessing the database content. Three main services are implemented:

- Query by Image predominant color and histogram.
- Query by Image layout.
- Query the database using a user specified digital image.

These advanced search tools are developed through the combination of web technologies such as PHP and Java Applets, embedded SQL, C++ and Dynamic Link Libraries (DLLs), all presented with simple HTML and XML forms.

For example the Query by Image Layout is considered. The user is able to draw his query in terms of colored rectangular and circles. Considering that the Web Server is installed in a different platform than the Database Server, in order to improve performance and interoperability, a Query by Image Layout involves the following steps:

- The user draws his query with the support of a Java

Applet that provides for basic shapes and colors.

- A temporary file is created in the Web Server with PHP graphic libraries and commands, which is representing the user-driven query.

- A COM object is instantiated by PHP. The COM object is an ActiveX Control, which is a system registered Dynamic Link Library (DLL). The COM object is created with C++. The main functions of the COM object is the connection with the database, the necessary file format conversions of the temporary image (so as the transparency colors to be preserved), the import of the image in the database and the disconnection from the database. The image is stored in the database externally and as a result a temporary file is created in the Database Server. The COM object is also compiled as .so (shared object) file for UNIX platforms.

- An SQL statement is used for fetching a result set using success indicators and percentage of similarity, deleting the temporary fields and tuples.

- PHP is used to format and present the result-set in HTML tables and to delete all the Web Server's temporary images.

- The QBIC Layout search is a multi-user search tool.

```
<HTML>

    <? PHP

    $SQL = "SELECT imageid, mmdbsys.qbscorefromstr

    ('texture file=<SERVER, \"$tmp$Serverfile\">', IMAGE)

    from prax.basicimage order by 2 asc");

    $TemporaryFile;
    $TemporaryFileNames;
    $DeletionRoutines;


    $instance = com(QueryImage.Query);
    DLL instantiation
    Connect with Database
    File Format Conversion
    Import Image to Database
    Disconnect from Database
    ?>




    <!APPLET>
            LayoutSearch.class
            ColorSelection.class
            ColorSlider.class
            ColorSquare.class
            ColorPercentageGuage
            BrightnessSlider.class
            ImageButton.class
            ImageCanvas.class
    </APPLET>


</HTML>
```

Query by Image Layout – Structure

IX. CONCLUSION – FUTURE EXTENSIONS

The general system architecture is based on the effective combination of several techniques and new technologies. Web technologies, databases, copyright management and protection techniques were exhaustively evaluated and studied. The main innovation of the system is that it is a real application that serves the digitization, management and protection of digital cultural heritage in an interoperable and distributed way.

The future extension of the system should aim at the enhancement of its educational purpose and the implementation of value-added services for the digitized material.

Firstly the web-based digital collection should be multilingual. Until today the content is presented only in Greek and this is an important drawback. The site should be translated at least in English, Italian, German, French, Spanish and Portuguese.

Enhancement of the educational purpose of the Web-based digital collection could be achieved by implementing on-line educational games and contests based on the digital content. In addition, a user should be able to create his personal digital collection based on common facts and characteristics of the cultural objects. For example, a user wants to create a collection consisting of ancient plates that refer to Ulysses and his imaginary journey. The user already has the ability to search for plates (layout search with a circle as a query) and refine his search by querying for metadata related to Ulysses. The user should as well have the ability to store his queries and selection of results for future use.

An online content management system is also under consideration. A Java-based user interface will assist archaeologists and photographers in managing digital images over the web.

X. REFERENCES

[1] ACM Publications, "Intellectual Property in the Age of Universal Access", 1999.

[2] Computer Science and Telecommunications Board, National Research Council, "The Digital Dilemma – Intellectual Property in the Information Age", National Academy Press, 1999.

[3] Digital Imaging Group, "Inc: DIG35 Specification - Metadata for Digital Images. Version 1.0", August 30, 2000.

[4] Fabien A. P. Petitcolas, Ross J. Anderson, "Evaluation of copyright marking systems".

[5] F. Bartolini, G. Bini, V. Cappellini, A. Fringuelli, G. Meucci, A. Piva, M. Barni, "Enforcement of Copyright Laws for Multimedia Through Blind, Detectable, Reversible Watermarking".

[6] F. Bartolini, R. Cardelli, V. Capellini, A. De Rosa, A. Piva, "Digital Watermarking: A Solution to Electronic Copyright Management Systems Requirements", WWW9 Culture Track, Amsterdam 2000.

[7] G. E. Kalamaras, D. K. Tsolis, G. K. Tsolis and T. S. Papatheodorou: Evaluation of Watermarking Techniques and Implementation of a Metadata Schema, for the Protection and Management of the Copyrights and Intellectual Property of Digitized Material of the Hellenic Cultural Heritage. Cultural Heritage Networks Hypermedia and Medici Framework Day, 16th - 19th September, 2000, Milano (available on-line at http://www.cultheritage.polimi.it/events/benire00/html/speakers/tsolis.htm).

[8] G. E. Kalamaras, G. K. Tsolis, D. K. Tsolis, P. A. Zafiris and T. S. Papatheodorou: Intergrated Environment for the Management,

Protection and Exploitation of Digitized Material of the Hellenic Cultural Heritage. WWW9 - Culture Track, May 16th - 19th, 2000, Amsterdam (on-line at http://www.medicif.org/dig_library/StateArt/Museums_Case_Study/Tsol is/tsolis.html).

[9] G. K. Tsolis, D. K. Tsolis and T.S Papatheodorou, "A watermarking environment and a metadata digital image repository for the protection and management of digital images of the hellenic cultural heritage", International Conference on Image Processing 2001 (ICIP 2001), Image Processing and Cultural Heritage, Thessaloniki, Greece, October 2001.

[10] G. K. Tsolis, D. K. Tsolis and T.S Papatheodorou, "An Advanced Digital Image Repository and an XML-based application for Intellectual Property Protection and Management of Digital Objects", WebNet 2001, Orlando, October 2001.

[11] George Voyatzis, Ioannis Pitas, "Protecting Digital-Image Copyrights: A Framework", IEEE Computer Graphics and Applications, pp. 18-24, January/February 1999.

[12] IBM, "IBM DB2 Digital Library", http://www.ibm.com.

[13] M. Kutter, and F.A.P Petitcolas, "A fair benchmark for image watermarking systems", Electronic Imaging '99, Security and Watermarking of Multimedia Contents, Sans Jose, CA, USA, 25-27 January 1999.

[14] N. Nikolaidis, I. Pitas, "Digital Image Watermarking: an Overview".

[15] The Apache Software Foundation. (2001). The Apache XML Project. http://xml.apache.org/.

[16] The IBM AlphaWorks. (2001). XML Access Service Lightweight Extractor (XLE). http://www.alphaworks.ibm.com/tech/xle.