

# Integrated Multimedia Medical Data Agent in E-Health

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## Abstract

E-Health is producing a great impact in the field of information distribution of the health services to the intra-hospital and the public. Previous research have addressed the development of system architectures in the aim of integrating the distributed and heterogeneous medical information systems. The easing of difficulties in the sharing and management of medical data and the timely accessibility to these data is a critical need for health care providers. We have proposed a client-server agent that allows a portal to the every permitted Information System of the Hospital that consists of PACS, RIS and HIS via the Intranet and the Internet. Our proposed agent enables remote access into the usually closed information system of the hospital and a server that indexes all the medical data which allows for in-depth and complex search queries for data retrieval.

*Keywords:* System interoperability; XML; XSLT; Multimedia Database; E-Health

## 1 Introduction

E-Health can be viewed as an emerging field in the intersection of medical informatics, public health and business, referring to health services and information delivered or enhanced through the Internet and related technologies (Eysenbach 2001). The main improvements the E-Health raises are the improving care efficiencies between General practitioner's (GP), hospitals, and the patients by increasing the quality of clinical communication. There are often inconsistency and timeliness of communication between the GP and the hospital or within the hospitals departments regarding the patient's medical records that can lead to the quality of care. Currently, there is increase in demand for remote access and interoperability to the information systems of the hospitals (ISH) that mainly consists of following systems. Picture Archiving and Communication Systems (PACS) used in medical image management and distribution including the Computed Tomography (CT), Magnetic Resonance Imaging (MRI), Positron Emission Tomography (PET) and Single-Photon Emission Computed Tomography (SPECT) image types, Hospital Information System (HIS) for the handling of health care tasks such as administration of the hospitals business transactions and the Radiology Information System (RIS)

designed to support administrative and clinical operations of the radiology department (Huang 1999). The integration of all the systems to reach interoperability and the support for remote access allows for efficiency and productivity in information management, sharing and distribution. The ease by which the Internet is able to distribute information to geographically separated users, its broad availability, and due to the rapid progress in public networking facilities provides a useful infrastructure for the communication to the hospital IS for medical data (Hwang 2000).

The objectives of this paper are to address the problems of system interoperability that goes beyond just the information systems connectivity but allow components to share and distribute medical data efficiently internally or externally from the hospital environment. Figure 1 describes the architectural design for such system. It is possible to investigate the need for the development of remote distribution of the integrated multimedia medical data from the ISH as well as evaluating the performance and the benefits.

## 2 Method

Previous research on information systems used in hospital tends to divide in two categories: PACS development and the integration of the information system. Researches in PACS have lead to successful implementations and results, studies mainly concerned with information distribution and new methods in data representations. The potential for PACS to communicate with outside network of the hospital environment is desirable and possible with the rapid advancement in Information Technology (Hwang 2000, Brelstaff, Mpehrs, and Anedda 2001). Secondly, the system integration has been focused on addressing the structure and development of the integrated system architecture (Jonher, Muller, and Reinshagen 2000, Grimson 1998, Bukhres and Hoang 1999). These concepts of integration, even though successful seldom have low barriers to adoption due to sheer size in complexities of reengineering.

In this study, we present a client-server system consisting of web enabled data browser to communicate to a server that consolidates the HIS. The client-server architecture is defined as follows. The server is connected to the various information systems and receives input from these systems that is parsed and stored in the database. The client then queries to this server, extracting the required information.

The technology used for this system was considered with data representation and multimedia support being the highest priority. The JAVA development tools of J2EE (enterprise edition) and the use of Cloudscape database for the development of the server and the J2SDK standard edition for web-based/stand-alone client application has lead to the development of a system fulfilling the above conditions.

This system concentrates on efficient data indexing and retrieval through the use of both internal and external network while minimizing integration requirements and maintaining the operations of the existing ISH. The function of each one of the components of the proposed portal system and the implementation details is described in the following sections.

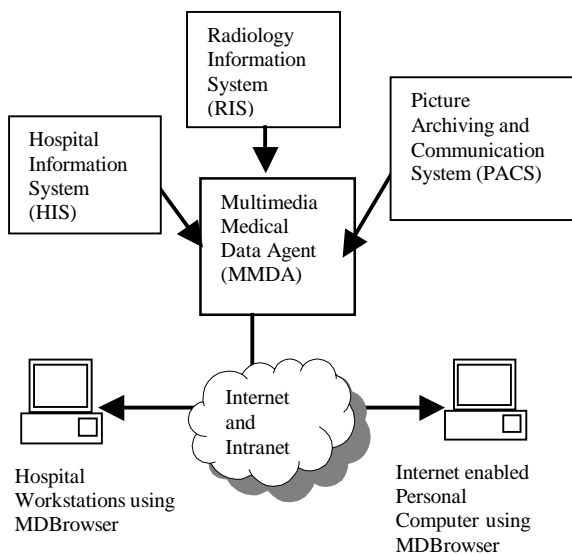


Figure 1: The overall system architecture.

## 2.1 Server Application: Multimedia Medical Data Agent (MMDA)

MMDA is an agent to the ISH that requires integration with the hospital departments IS to archive interoperability. It acts as a broker, performing an integration service on behalf of all the system components, and as a client-server for web-based medical data browser (MDBrowser) application. In other words, the MMDA consolidates the ISH by indexing all the data used in the ISH. The indexing is performed by the use of the “information shelling” parsing method. Upon receiving of the input data, the input is parsed and then stored in the MMDA database server. Once the data is indexed, a request to the MMDA for certain data will connect to the PACS, RIS and HIS to retrieve the data if necessary (Figure. 2). Depending on the distribution requirement, the data can be transformed for Internet and the Intranet. Internet content is archived by the compression of image using recommended JPEG Compression Ratios by Medical Experts to accommodate low bandwidth of the Internet. For the internal hospital distribution, raw data format is used. The ability of the MMDA to be accessed by the web-based application MDBrowser has many significant advantages; distant communication and system independence being some of

the benefits. However the main benefit that is introduced by this concept is the ability to establish a connection to the data of the ISH that are usually only available within the hospital environment. This can be viewed as an external *portal* to the hospital information systems including the PACS, HIS and the RIS

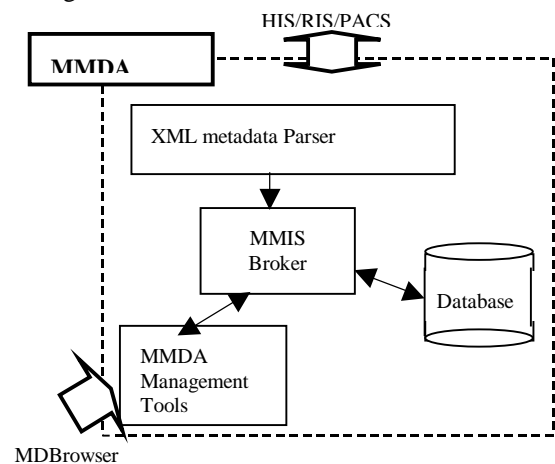


Figure 2: The internal structure of the MMDA.

## 2.2 Information Shelling

The method of “information shelling” is for the representation of medical data. This uses the concept of metadata, it’s definition defined according to IEEE Mass Storage System and Technology Committee’s (Curuts, Foster, and Stentiford 1999), which enables intelligent, efficient access and management of data. The metadata for medical data must be proposed on an in-depth understanding and requirement criteria’s for the intended audience usage. Hence in the case of medical data, it should be applied for search, retrieval and storage, medical data security, and data integrity.

Metadata is used as an information header for all the medical data. Once the header is created, the actual data is abandoned with keeping only the information that can be used to retrieve the original data for the purpose of indexing to be stored in MMDA server. The shell is implemented using XML document to express medical data in a structured and manipulative format that is both human readable and optimized for machine interpretation. XML, developed by the World Wide Web Consortium is a powerful hierarchical data model that allows documents to be self-describing, handles and manages large information repositories as well as providing rules for integrity (WWW consortium).

The metadata header content shown in Table. 1 allows for the data’s identity in terms of data format, time of creation etc and also the ability to search and retrieve the data. The accessing of the data also updates the header to include information that can be used for security reasons and renewal or updates to the data. The advantage of having the data in XML shell is that it can be combined to other XML documents using XML Style-sheet Language for Transformation (XSLT). As an example, a patient may require services from both the nuclear medicine department and the radiology department. This means that this patient has three data sets from HIS for

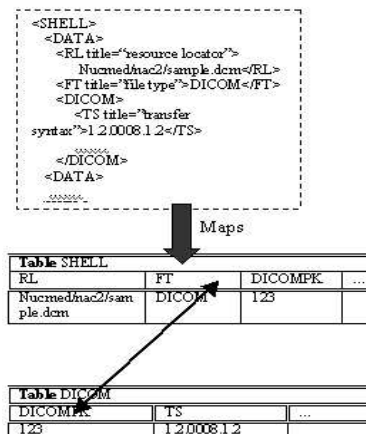
administrative report (HL7), from RIS for radiology report (HL7), and also from Nuclear medicine department with nuclear images (DICOM). Since all the data belong to the same patient, it can be combined into single document that is more convenient and efficient. Also the data can be validated easily with the use of Data Type Definition (DTD) for the XML document and the use of XSLT for presentational format transformations.

Information Type	Definition and Usage
Date of Creation (DC), Last date of access (DA), Date of Store (DS)	As the name suggests. The DA field is updated with every retrieval and DS with every update.
Patient Identification Number (PID)	The common hospital wide patient identification number.
Resource Locator (RL)	The location of the resource.
Resource Retrieval Method (RRM)	Where the data is stored and how it can be retrieved. E.g. PACS server as the location and PACS communication protocol for retrieval.
Data Format (DF)	The data format type such as DICOM, HL7.
Access Permission Level (APL)	The level of authority for the retrieval of the user. Security mechanism to avoid unauthorized usage.
Data specific Contents.	Space allocated for data specific contents such as information extracted from DICOM and HL7.

Refer to Fig. 2 for sample XML document with the defined header and how the Data specific content is used.

**Table 1: Metadata header.**

Once the shell is created, the XML document is mapped into the XML database server. The use of relational database that maps all the tags and fields of the XML document into tables and columns allows for all the information in the XML document to be stored and retrieve in full context (Figure. 3). This XML mapped database allows complex and precise search of the database using SQL and store information in a very efficient way for machine interpretation (Bourret 2001).



**Figure 3: Mapping of the XML shelled document into the database.**

### 2.3 Client Application: Medical Data Browser (MDBrowser)

The client in this client-server system is the use of web-based MDBrowser. This is an image viewing and patient record display application that supports the two most popular Web browsers (Internet Explorer and Netscape Navigator). The initial development of such application is presented in (Feng, Cai, Kim and Lim 2001). This has provided knowledge of what is required for optimal performance towards its intended audience of medical staffs in nuclear and radiology department. Described here is the second version.

MDBrowser has the ability to search the MMDA server using SQL and/or predefined query (Figure. 4), which in term execute the retrieval of the data by the MMDA from the various information systems. Searching can be very extensive with every table and columns in the database if desired can be used in the query. In other words, entire metadata of the medical data can be queried. Such abilities can be helpful in narrowing the search for very specific contents of the data as well as for data related statistical analysis.

MDBrowser supports medical image examinations by the inclusions of online multimedia tools such as Region of Interest (ROI), Scaling, Color filtering, Cine sequence player, multi-frame image viewer, and Image fusion. (Figure. 5) Also the use of graphically rich clinical reporting tools are available for studying and editing of the electronic patient reports which supports the inclusion of images, video and hypertext links to related information within the report.

## 3 Results

The MMDA and MDBrowser can be seen as a kind of intermediate solution between the current semi-integrated status of the ISH and the fully integrated ISH of the near future. This is archived by the method of indexing that integrates the IHS and allows retrieval of the data from both the internal and external environment.

The execution of the MDBrowser can be seen on Figure. 4. The interface is split in three sections by tabbed windows, which includes search engine, image viewer, and the report viewer. The client can start a session from any location having Internet access by establishing a secure password protected TCP/IP connection to the MMDA server. Once connected, the client can search the MMDA for desired content, which is then sent to the user upon selection that can be studied using tools available in the MMDA (Figure. 5 and 6).

The prototype MMDA and the MDBrowser is currently being adapted for use in Royal Prince Alfred Hospital, Sydney (RPAH). This site constitutes information systems that includes HIS, RIS and the PACS. The initial experiment will focus mainly on the communications with the PACS and the sub division of the HIS, the nuclear department information system. Currently, only

DICOM and HL7 medical data format is supported, as these are the data type used in the RPAH. The system independence and low adaptation requirement of the MMDA should be of great benefit because it offers integration of additional networked resources without the significant increase in overall system architecture.

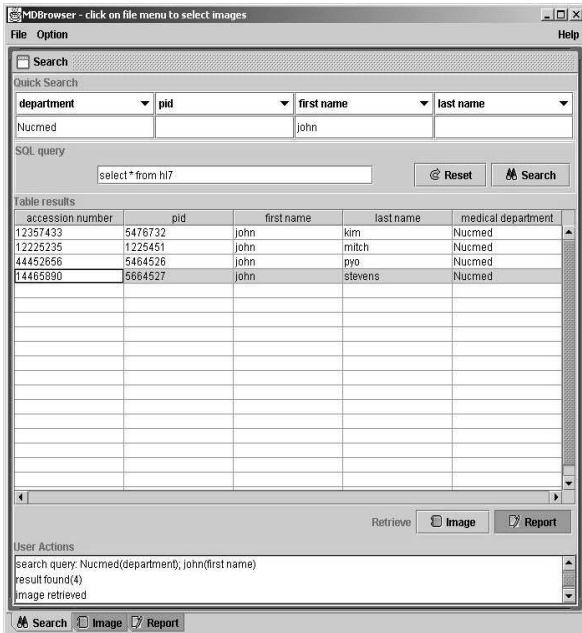


Figure 4: MDBrowser’s search interface showing the result table and the search query.

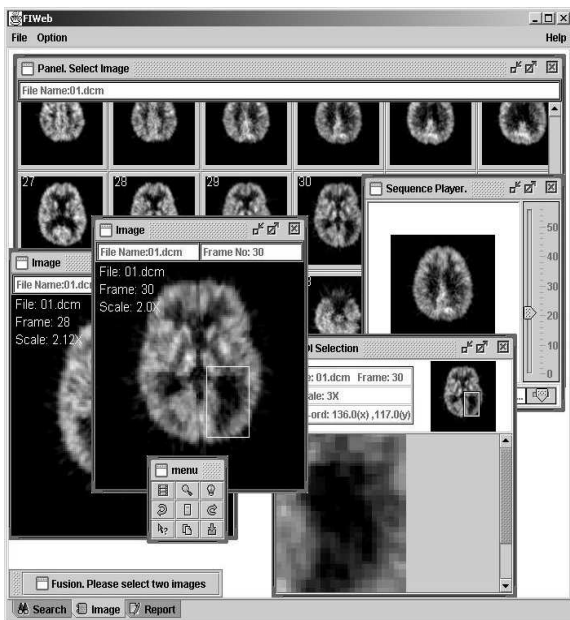


Figure 5: MDBrowser’s medical study interfaces displaying many of the available multimedia tools for diagnostic purposes.

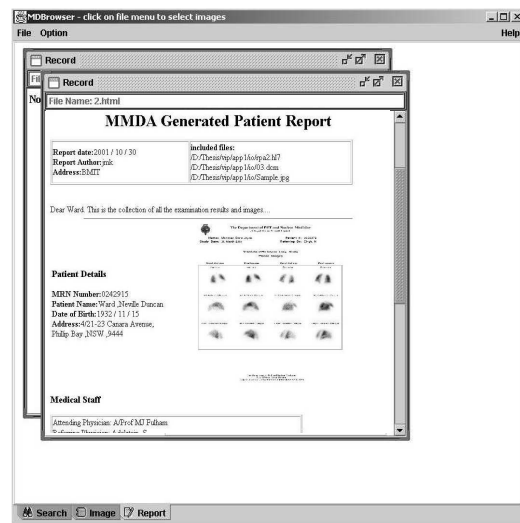


Figure 6: MDBrowser’s Report study interface that displays multiple multimedia reports.

#### 4 Conclusion

The design of client-server system that utilizes the web technology and data management for communication and system interoperability to the IHS has been presented in this paper. The use of MMDA and MDBrowser can resolve the closed access to the hospital information systems for the benefits of GP and patients. It also allows for enhanced search and retrieval of medical. The potential that is introduced by this system are the ability of remote access to the usually closed ISH; web-enabled medical data browser; and the indexing of the medical data of the ISH that can be efficiently searched and retrieved.

Security is an issue that must be resolved before the successful implementation of any system that allows external network into the private data that are circulated in the hospital. Security provided in the web browser is not enough, hence more secure and protective method is required. Research on applying encryption and digital watermarking is actively conducted within our research group, aiming to resolve this issue.

In the future, areas of interest that are to be further researched in E-Health is the full support of all medical data standards such as GIF image format, Voice, American Society for Testing and Materials (ASTM) and all other standardized medical data formats. Also the adaptation of automatically generated distribution reports to outpatients, GPs etc that can be applied to the proposed system architecture easily.

#### 5 Acknowledgement

This research is supported by the ARC, UGC and CMSP Grants.

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